Section I—Air and Fallout

GROSS BETA ACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of gross beta activity in air and precipitation provides one of the earliest and most sensitive indications of changes in environmental fission product activity. Although this surveillance does not provide enough information to assess total human radiation exposure from fallout, it is used as an alerting system for determining when to intensify monitoring in other phases of the environment.

Surveillance data from a number of national programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

1. Radiation Surveillance Network May 1965

Division of Radiological Health
Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) of the PHS Division of Radiological Health, which regularly gathers samples from 75 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Alerting function

The alerting function of the network is provided by field estimates of the gross beta activity of airborne particulates on the filters. These determinations are performed about 5 hours after the end of the sampling period to allow for decay of the naturally occurring radon daughters. The daily field readings are submitted to the Radiation Surveillance Center, Division of Radiological Health, Washington, D.C. These field estimates are reported elsewhere on a monthly basis (*1*). When unusually high air levels are observed, appropriate Federal and State officials are promptly notified.

Air sampling procedure and results

Airborne particulates are collected continuously on carbon-loaded cellulose dust filters 4 inches in diameter. About 1,800 cubic meters of air are drawn through each filter during the 24-hour sampling period by a high volume centrifugal blower.

The filters are forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, where the gross beta activity is measured using a thin-window, gas-flow proportional counter, calibrated with a strontium–90—yttrium–90 standard. Each filter is counted 4 days after the end of the sampling period and again 7 days later if the net count rate is 2,000 cpm or higher. The initial four-day aging of the sample eliminates interference from naturally occurring radon and thoron daughters. By using the two counts and the Way-Wigner formula (*2*), the age of fission products is estimated, and the activity extrapolated to the day of collection.[1] The May 1965 average gross beta concentrations in air for RSN stations are given in table 1. Time profiles of gross beta activity in air for eight RSN stations are shown in figure 2.

[1] If a sample contains a mixture of fresh and old fission products, the age estimated by the Way-Wigner formula is some intermediate value; consequently the calculated age of the fresh component will be overestimated.

Figure 1. Radiation Surveillance Network Sampling Stations

Radioactivity in precipitation

Continuous sampling for radioactivity in total precipitation is conducted at most stations on a daily basis, using funnels with collection areas of 0.4 square meter. A 500-ml portion of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory for analysis. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation is reported, but no analysis is made.

In the laboratory the gross beta activity in precipitation is determined by counting the evaporated sample by the same method used for analyzing the air filters, including the extrapolation to time of collection. Deposition (D) in nCi/m^2 for the sample is determined by:

$$D = \frac{CP}{1000}$$

where C is the concentration in pCi/liter, and P is the depth of precipitation in mm. The individual values of deposition and depth of precipitation are totaled for the month. Total depths of precipitation and deposition of radioactivity during May 1965 are presented in table 1.

Observation of fresh fission products

During May 1965, 90 air and precipitation samples were analyzed by gamma spectrometry. The method discussed by Burrus (*3*) and Covell (*4*) was adapted for resolving the gamma scan data. Eighty-seven of the samples were found to contain fresh fission products (short-lived radionuclides) in addition to long-lived radionuclides. Although the increases in air activity were not as pronounced as those observed following the first nuclear test on the Chinese mainland, the time relationship between the second detonation that took place on May 13, 1965 (10:00 p.m. EDT) and the influx of the fresh material is reasonably consistent with previous observations.

Table 1. Gross beta activity in surface air and precipitation, May 1965

Station location		Air surveillance					Precipitation measurements	
		Number of samples	Gross beta activity, pCi/m³			Last profile in *RHD*	Total depth (mm)	Total deposition (nCi/m³)
			Maximum	Minimum	Average [a]			
Ala:	Montgomery	30	0.60	<0.10	0.31	May 65	7.4	1.5
Alaska:	Adak	30	0.56	<0.10	<0.17	Jul 65	[b]	
	Anchorage	29	0.39	<0.10	<0.14	May 65	13.4	2.9
	Attu Island	22	0.63	<0.10	<0.15	Dec 64		
	Fairbanks	22	0.54	<0.10	<0.18	Jun 65	1.1	0.2
	Juneau	11	0.39	<0.10	<0.20	Jul 65	20.0	4.0
	Kodiak	8	0.14	<0.10	<0.10	Aug 65		
	Nome	0				Feb 65		
	Point Barrow	31	0.49	<0.10	<0.11	Jan 65		
	St. Paul Island	28	0.62	<0.10	<0.14	Mar 65		
Ariz:	Phoenix	28	8.81	0.19	1.22	Jul 65		
Ark:	Little Rock	26	0.89	<0.10	0.36	Jun 65	52.9	10.7
Calif:	Berkeley	22	0.61	<0.10	0.22	Aug 65		
	Los Angeles	31	0.73	0.18	0.27	Feb 65		
C. Z:	Ancon	0				Aug 65		
Colo:	Denver	28	7.43	0.17	0.93	Aug 65	45.9	11.5
Conn:	Hartford	31	1.03	<0.10	0.29	Jul 65	45.9	11.6
Del:	Dover	25	1.47	<0.10	0.37	May 65		
D. C:	Washington	28	1.56	<0.10	0.40	Feb 65	39.0	11.9
Fla:	Jacksonville	29	0.58	0.18	0.40	Jun 65	17.8	4.4
	Miami	30	0.63	0.15	0.38	Jul 65	2.5	0.5
Ga:	Atlanta	27	0.60	0.13	0.29	Apr 65		
Guam:	Agana	30	17.93	<0.10	1.91	Apr 65		
Hawaii:	Honolulu	31	2.10	<0.10	<0.30	Dec 64	161.2	32.30
Idaho:	Boise	30	1.39	<0.10	0.48	Dec 64	19.2	8.6
Ill:	Springfield	28	0.71	<0.10	0.36	Feb 65	47.5	10.2
Ind:	Indianapolis	28	0.66	0.13	0.35	Apr 65	34.0	15.7
Iowa:	Iowa City	31	2.79	<0.10	0.44	Aug 65	128.0	35.2
Kans:	Topeka	22	2.57	0.11	0.46	May 65	47.5	29.1
Ky:	Frankfort	30	1.48	0.16	0.49	Feb 65	32.8	10.2
La:	New Orleans	29	0.85	0.11	0.34	Feb 65	161.1	44.9
Maine:	Augusta	31	1.30	<0.10	0.32	Mar 65	23.5	5.3
	Presque Isle	25	1.48	<0.10	0.28	Aug 65	71.1	19.9
Md:	Baltimore	24	1.53	<0.10	0.45	Jul 65	40.0	9.5
	Rockville	15	1.82	0.17	0.46	Jan 65		
Mass:	Lawrence	31	1.28	<0.10	0.36	May 65	44.5	12.6
	Winchester	24	1.22	<0.10	0.33	Jul 65	41.2	9.9
Mich:	Lansing	31	1.73	<0.10	0.41	Jan 65	25.9	10.4
Minn:	Minneapolis	27	0.91	<0.10	0.29	Apr 65	107.2	41.6
Miss:	Jackson	29	1.09	0.21	0.44	Dec 64	25.7	5.3
	Pascagoula	19	1.04	0.16	0.66	Jul 65		
Mo:	Jefferson City	30	1.06	<0.10	0.37	Apr 65	93.3	39.2
Mont:	Helena	30	2.19	<0.10	0.56	Jul 65	50.3	13.8
Nebr:	Lincoln	17	2.02	<0.10	0.43	Mar 65	183.7	36.5
Nev:	Las Vegas	27	8.96	0.31	1.44	Jun 65		
N. H:	Concord	25	1.88	<0.10	0.43	Feb 65		
N. J:	Trenton	31	1.42	<0.10	0.41	Mar 65	2.5	1.5
N. Mex:	Santa Fe	28	2.71	0.13	0.64	Jul 65	24.6	9.2
N. Y:	Albany	27	0.77	<0.10	0.30	Apr 65	21.9	4.2
	Buffalo	22	1.51	<0.10	0.45	Aug 65		
	New York	29	1.30	<0.10	0.27	Jul 65		
N. C:	Gastonia	30	0.65	0.11	0.29	Aug 65	49.9	10.0
N. Dak:	Bismarck	29	1.55	<0.10	0.41	Jan 65	161.7	67.9
Ohio:	Cincinnati	7	0.54	0.19	0.31	May 65		
	Columbus	29	2.48	0.15	0.63	Mar 65	89.4	55.7
	Painesville	29	1.39	<0.10	0.43	Jul 65	86.8	25.4
Okla:	Oklahoma City	28	1.10	<0.10	0.36	Jan 65	104.9	
	Ponca City	29	0.65	<0.10	0.19	Jul 65	31.2	22.1
Ore:	Portland	31	0.88	<0.10	0.38	Mar 65	33.8	6.7
Pa:	Harrisburg	31	1.77	<0.10	0.35	Apr 65	349.2	10.5
P. R:	San Juan	30	0.38	<0.10	<0.13	Mar 65	45.6	62.8
R. I:	Providence	30	1.12	<0.10	0.29	Jan 65	19.5	10.6
S. C:	Columbia	28	1.10	0.12	0.31	Jul 65	34.1	4.2
S. Dak:	Pierre	30	2.63	<0.10	0.47	Jul 65	78.8	15.1
Tenn:	Nashville	30	0.74	<0.10	0.30	Jan 65	225.9	20.6
Tex:	Austin	26	1.32	<0.10	0.34	May 65	8.1	45.4
	El Paso	30	3.60	<0.10	0.68	Jan 65	49.8	1.6
Utah:	Salt Lake City	30	15.58	<0.10	1.52	Feb 65	9.2	44.3
Vt:	Barre	30	1.33	<0.10	0.42	Jun 65	35.8	3.2
Va:	Richmond	30	2.16	<0.10	0.42	Jun 65	25.5	44.3
Wash:	Seattle	31	0.31	<0.10	<0.16	May 65	10.6	44.9
	Spokane	31	1.55	0.11	0.39	Apr 65	50.6	7.9
W. Va:	Charleston	29	0.60	0.12	0.30	Jul 65	41.2	40.3
Wis:	Madison	30	1.48	<0.10	0.31	Jun 65	81.5	54.4
Wyo:	Cheyenne	31	5.62	<0.10	0.82	Jun 65		35.1
Network summary [c]		1986	17.93	<0.10	0.43		60.3	20.3

[a] The monthly average is calculated by weighting the individual samples with the length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the values used in the average, a less-than sign is placed before the average.

[b] Blank indicates no report received.

[c] For the network summary, all averages are arithmetic means of station averages.

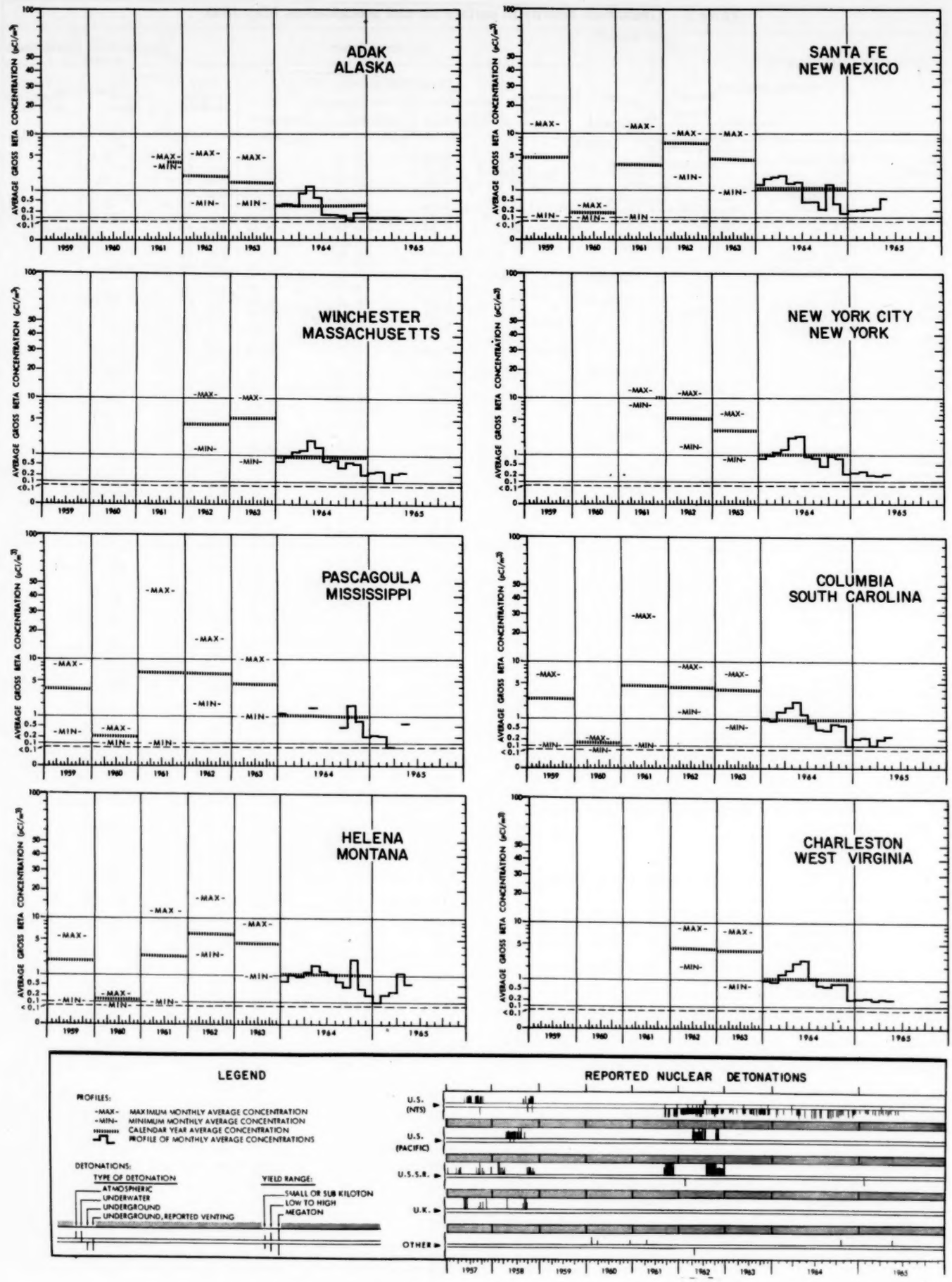

Figure 2. Monthly and yearly profiles of beta activity in air—Radiation Surveillance Network, 1959—May 1965

2. Canadian Air Monitoring Program[2] May 1965

Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations (figure 3) are located at airports, where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*5–9*).

[2] This report was prepared from information and data in the June 1965 monthly report, "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

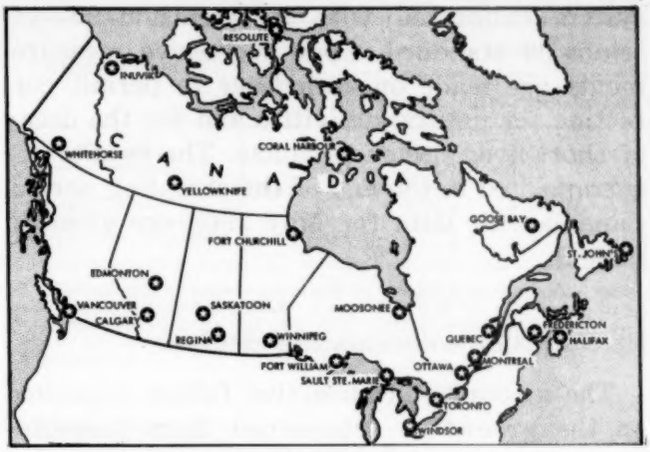

Figure 3. Canadian air and precipitation sampling stations

Air sampling procedure and results

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high efficiency 4-inch diameter glass fiber filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa.

For analysis purposes a 2-inch diameter disk is cut from each filter and counted with a thin end-window, gas-flow, Geiger-Mueller counter

Table 2. Canadian gross beta activity in surface air and precipitation, May 1965

Station location	Air surveillance				Precipitation measurements	
	Number of samples	Gross beta activity, pCi/m³			Average concentration, (pCi/liter)	Total deposition (nCi/m²)
		Maximum	Minimum	Average		
Calgary	31	2.2	0.0	0.6	208	9.2
Coral Harbour	31	0.2	0.0	0.1	73	2.2
Edmonton	31	0.6	0.1	0.3	340	25.1
Ft. Churchill	31	0.3	0.0	0.2	85	4.4
Ft. William	24	2.1	0.0	0.4	1,503	114.8
Fredericton	29	1.1	0.0	0.3	172	11.6
Goose Bay	31	0.4	0.0	0.1	114	6.8
Halifax	30	0.5	0.0	0.2	592	13.4
Inuvik	31	5.5	0.1	0.4	114	3.4
Montreal	31	1.5	0.0	0.5	482	22.1
Moosonee	30	2.2	0.0	0.3	323	24.5
Ottawa	30	1.2	0.0	0.3	329	11.9
Quebec	30	1.6	0.0	0.3	370	23.3
Regina	31	1.4	0.0	0.4	423	40.1
Resolute	31	0.3	0.0	0.1	279	1.6
St. John's, Nfld	30	0.4	0.0	0.1	101	8.4
Saskatoon	30	0.3	0.0	0.2	920	19.4
Sault Ste. Marie	31	2.1	0.0	0.4	197	20.8
Toronto	30	1.1	0.1	0.3	446	8.3
Vancouver	30	0.4	0.0	0.2	402	21.0
Whitehorse	31	0.4	0.0	0.2	251	1.9
Windsor	30	1.9	0.1	0.5	403	26.9
Winnipeg	30	1.7	0.0	0.3	565	51.6
Yellowknife	28	6.4	0.0	0.8	Trace	3.2
Average	—	1.5	0.0	0.3	378	19.8

system calibrated with a strontium–90—yttrium–90 standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for May 1965 are given in table 2.

Precipitation collection and analysis

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polyethylene-lined rainfall pots. The collection period for each sample is 1 month. After transfer of the water to the sample container, the polyethylene liner is removed, packed with the sample, and sent to the laboratory.

Strontium and cesium carriers are added to all samples on arrival at the laboratory. Other carriers are added to selected samples according to the specific radionuclides to be determined. The samples are then filtered and the filterate evaporated to near dryness. The filter paper containing insoluble matter is then ignited, together with the polyethylene liner at 450°C. The ash is combined with the soluble fraction, transferred to a glass planchet, evaporated under an infrared lamp, and then counted with a thin end-window Geiger-Mueller counter calibrated with a strontium–90—yttrium–90 source. Gross beta activities in air and precipitation for May 1965 are given in table 2.

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3. Mexican Air Monitoring Program May 1965

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), Mexico City. From 1952 to 1961 the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN (*10–14*).

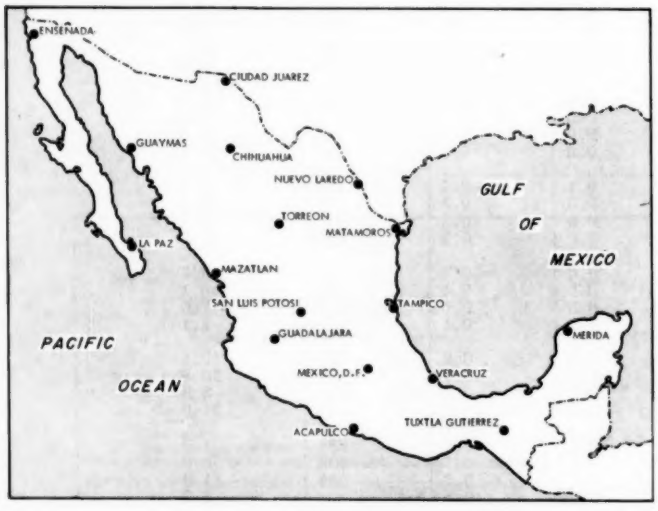

Figure 4. Fallout network sampling stations in Mexico

In 1961 the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. This consists of 17 stations (figure 4), 12 of which are located at airports and operated by airline personnel. The remaining 5 stations are located at Mexico City, Mérida, Veracruz, San Luis Potosí, and Ensenada.

Sampling

The sampling procedure involves drawing air for 24 hours a day, 3 or 4 days a week at the rate of approximately 1,200 cubic meters per day, through a high-efficiency, 6- x 8-inch glass fiber filter, using high volume samplers. After each 24-hour sampling period, the filter is removed and forwarded via airmail to the "Laboratorio de Estudios sobre Contaminación Radiactive," CNEN, in Mexico City for assay of gross beta activity. A minimum of three days after collection is allowed for decay of radon and thoron daughter natural radioactivity. Data are not extrapolated back to the date of collection.

Results

The maximum, minimum, and average fission product beta concentrations in surface air during May 1965 are presented in table 3.

Table 3. Gross beta activity of airborne particulates Mexico, May 1965

Station	Number of samples	Gross beta activity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	*			
Ciudad Juárez	12	2.2	0.1	0.8
Chihuahua	18	2.9	0.2	0.1
Ensenada	10	0.3	<0.1	0.2
Guadalajara	16	1.6	<0.1	0.3
Guaymas	9	0.6	0.1	0.4
La Paz	19	0.4	0.1	0.2
Matamoros	5	0.3	<0.1	0.2
Mazatlán				
Mérida	12	0.8	<0.1	0.2
México, D.F.	18	2.2	<0.1	<0.1
Nuevo Laredo	2			
San Luis Potosí	13	2.0	<0.1	0.3
Tampico	18	0.2	<0.1	0.1
Torréon	17	1.8	<0.1	0.3
Tuxtla Gutiérrez				
Veracruz				

* Blanks indicate stations temporarily shut down.

4. Pan American Air Sampling Program May 1965

Pan American Health Organization and Public Health Service

Gross beta activity in air is monitored by six countries in the Americas under the auspices of a collaborative program developed by Pan American Health Organization (PAHO) and the Public Health Service (PHS), for assisting countries of the Americas in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network.

The six air sampling stations included in the Program are operated by the technical staff of the Ministry of Health in each country. The station in Kingston, Jamaica, is operated by the Public General Hospital; in Caracas, Venezuela, by the Venezuelan Institute for Scientific Investigations; in Lima, Peru, by the Institute of Occupational Health; in Santiago, Chile, by the Occupational Health Service; in Trinidad, West Indies, by the University of the West Indies; and in Buenos Aires, Argentina, by the Ministry of Social Welfare and Public Health.

The May 1965 air monitoring results from the six participating countries are given in table 4.

Table 4. Gross beta activity in air, PAHO, May 1965

Sampling stations	Number of samples	Gross beta activity, pCi/m³		
		Maximum	Minimum	Average *
Kingston, Jamaica	21	0.21	<0.10	<0.11
Caracas, Venezuela	20	0.16	<0.10	<0.10
Lima, Peru	19	0.10	<0.10	<0.10
Santiago, Chile	29	0.12	<0.10	<0.10
Trinidad, West Indies	0	—	—	—
Buenos Aires, Argentina	0	—	—	—

* The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the values used in the average, a less-than sign is placed in front of the average.

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MONTHLY DEPOSITION OF VARIOUS RADIONUCLIDES

For the purpose of this section the word "fallout" refers to the deposition of radioactive materials on the earth's surface, normally expressed in terms of the activity of selected radionuclides deposited on a unit area during a given period of time. Unless otherwise stated, fallout measurements include both precipitation and dry fallout (settled dust).

Reports of fallout measurements at selected stations in North and South America are presented below.

1. Fallout in the United States and other areas April–December 1964[1]

Health and Safety Laboratory
Atomic Energy Commission

Monthly fallout deposition rates for strontium–90 are determined by the Health and Safety Laboratory (HASL) for 44 sites in the United States and 104 locations in other countries.

Two methods of fallout collection are employed by HASL. In the first, precipitation and dry fallout are collected for a period of one month in a stainless steel pot with an exposed area of 0.076m^2. At the end of the collection period, the contents are transferred, by careful scrubbing with a rubber spatula, to a polyethylene sample bottle which is then shipped to the laboratory for analysis.

The second method involves the use of a polyethylene funnel, with an exposed area of 0.07m^2, attached to an ion exchange column. After a 1-month collection, the inside of the funnel is wiped with a tissue, and the tissue is inserted in the end of the column, which is then sealed and sent to HASL for analysis. It has been shown that at the 95-percent confidence level there was no significant difference in the strontium–90 measurements obtained from samples collected by the two methods (*1*).

Results

Strontium–90 data from all of the United States stations and 26 other selected points in the Western Hemisphere (see figure 1) covering the period from April through December 1964 are summarized in tables 1 and 2. All the stations of the 80th Meridian Network, except Washington, D.C., are represented.

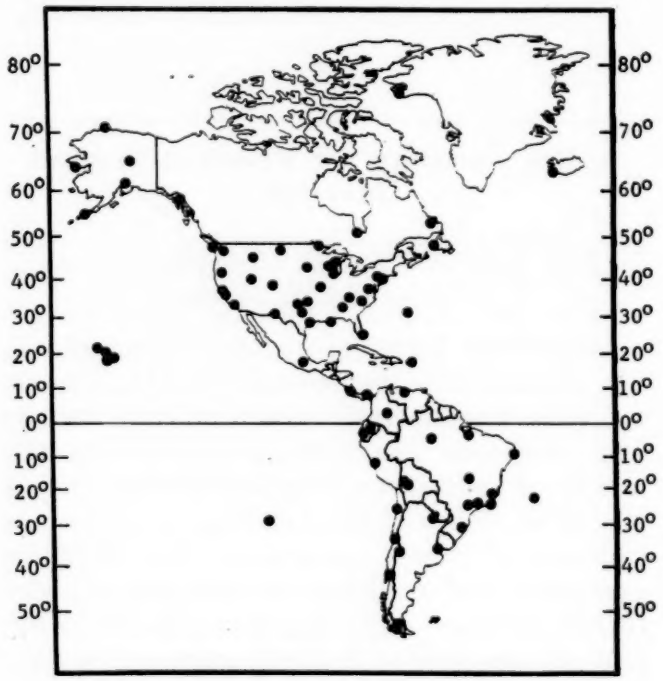

Figure 1. HASL fallout sampling stations

Stations at Westwood, New Jersey; Chattanooga, Tennessee; Seattle, Washington; Appleton, Wisconsin; Palo Alto, California; and Midwest City, Oklahoma, have collected monthly pot samples which have been analyzed for various radionuclides. The amount of precipitation at each station and the monthly deposition rates for strontium–89, strontium–90, cesium–137, cerium–144, zirconium–95 and manganese–54 at each station are presented in tables 3 and 4.

[1] The data in this article were taken from *Fallout Program Quarterly Summary Report, HASL–161*:5–203, Health and Safety Laboratory, AEC, New York, N.Y. 10014.

Table 1. Monthly strontium-90 fallout in the United States, HASL, April–December 1964

(Deposition in nCi/m²)

Sampling location and type of collection		April	May	June	July	August	September	October	November	December
Ala:	Birmingham (pot)	0.29	1.06	2.30	1.35	0.58	0.29	—	—	0.01
Alaska:	Anchorage (col)	0.16	0.22	0.39	—	0.62	0.31	—	—	0.07
	Barrow (col)	[a]—	—	0.25	0.10	0.21	0.02	—	—	[c]
	Cold Bay (col)	0.87	1.15	1.03	1.14	0.90	0.60	—	—	0.43
	Fairbanks (col)	0.22	0.44	1.37	0.01	0.61	0.14	—	—	0.07
	Juneau (col)	—	3.93	2.70	1.21	0.86	0.02	—	—	0.33
	Nome (col)	—	0.28	0.03	0.15	0.05	0.48	—	—	—
Calif:	W. Los Angeles (pot)	0.04	0.03	—	0.02	0.06	0.10	—	—	0.10
	Palo Alto (pot)	0.05	0.22	0.12	0.03	0.08	0.01	0.10	0.33	0.49
	Palo Alto (col)[b]	0.07	0.22	0.12	—	—	—	—	—	—
	San Francisco (col)	0.12	0.21	0.17	0.05	0.04	[c]	—	—	0.52
Colo:	Denver (col)	0.32	1.47	4.58	1.31	0.30	0.19	—	—	0.15
Fla:	Coral Gables (pot)	—	3.02	2.14	0.97	0.53	0.25	0.07	0.05	0.05
	Miami (col)	0.96	2.06	2.00	1.17	0.46	0.30	—	—	0.24
Hawaii:	Hilo (col)	1.88	6.85	0.25	1.85	0.94	0.81	—	—	0.38
	Honolulu (pot)	1.19	1.19	0.70	0.78	0.58	0.42	—	—	0.05
	Litlue (col)	1.73	0.84	4.41	0.78	0.35	0.19	—	—	0.10
	Mauna Loa (col)	0.23	0.23	0.01	0.20	0.06	0.35	—	—	0.09
Ill:	Argonne (pot)	2.74	1.19	3.22	0.80	0.53	0.39	—	—	0.04
La:	New Orleans (col)	1.87	0.47	0.94	0.91	0.44	0.16	—	—	0.17
Minn:	International Falls (col)	1.84	3.05	0.49	1.58	0.81	0.29	—	—	0.07
Mo:	Columbia (col)	1.68	3.74	1.87	1.24	0.30	0.29	—	—	0.14
Mont:	Helena (col)	0.46	1.43	2.76	1.09	0.59	0.17	—	—	0.10
N. J:	Westwood (pot)	2.58	0.86	2.39	1.07	0.43	0.11	0.31	0.34	—
	Westwood (col)	—	0.80	1.84	—	—	—	—	—	—
N. Y:	New York (pot)	4.73	0.53	2.55	1.28	0.39	0.23	0.29	0.32	0.56
N. Dak:	Williston (col)	0.29	0.72	2.94	0.34	0.49	0.20	—	—	0.24
Ohio:	Wooster (pot)	3.14	3.03	3.04	1.35	0.75	0.12	—	—	0.09
Okla:	Midwest City (pot)	1.33	2.54	0.73	0.46	0.54	0.42	0.36	0.46	0.04
	Tulsa (pot)	[d] 1.31	[d] 1.60	1.67	1.21	—	—	—	—	—
Ore:	Medford (col)	0.19	0.35	1.04	0.95	0.32	0.07	—	—	0.94
S. C:	Columbia (col)	0.74	1.14	1.34	1.54	0.48	0.28	—	—	0.32
S. Dak:	Vermillion (pot)	4.22	2.84	4.58	1.27	0.02	0.47	—	—	0.03
Tenn:	Chattanooga (pot)	4.40	2.11	1.43	0.86	0.73	0.19	0.43	0.21	0.05
Tex:	Dallas (col)	1.57	2.02	0.61	0.22	0.34	0.25	—	—	0.11
	El Paso (col)	0.34	0.05	0.19	0.59	0.17	0.27	—	—	0.07
	Houston (col)	0.38	0.54	0.49	1.76	0.21	0.09	—	—	0.24
Utah:	Salt Lake City (pot)	5.70	2.31	6.58	1.62	0.31	—	—	—	0.14
Va:	Sterling (U.S. Weather Bureau Center) (col)	1.89	0.71	0.81	0.76	0.33	—	—	—	0.32
Wash:	Seattle (pot)	1.54	1.87	1.15	0.68	0.33	0.30	0.18	0.80	0.62
	Seattle (pot)	1.47	1.83	2.56	0.85	0.48	0.35	—	—	0.12
	Tatoosh Island (col)	0.15	0.91	1.59	1.12	0.66	0.47	—	—	0.98
Wis:	Appleton (pot)	1.35	2.46	0.77	1.19	0.71	0.65	0.38	0.45	0.16
	Green Bay (col)	1.44	1.73	1.59	1.39	0.78	0.35	—	—	0.15

[a] Dash indicates data not available.
[b] Collection discontinued after June 1964.
[c] Zero or trace.
[d] Proportioned from originally consolidated data.

Table 2. Monthly strontium-90 fallout in North and South America, HASL, April–December 1964

(Deposition in nCi/m²)

Sampling location and type of collection		April	May	June	July	August	September	October	November	December
Bermuda:	Kindley AFB (col)	0.42	0.79	0.12	0.47	0.50	0.05	[a] —	—	0.37
Bolovia:	Chacaltaya (col)	0.02	0.02	0.04	0.02	0.01	0.07	—	—	0.05
	La Paz (Ovejuyo) (col)	0.03	0.03	0.01	0.07	0.03	0.07	—	—	0.10
	La Paz (City) (col)	0.02	0.02	0.01	0.03	0.03	0.07	—	—	0.08
Brazil:	Belem (col)	0.18	0.36	0.09	0.10	0.06	0.08	—	—	0.01
	Trinidade Island (col)	0.01	0.08	0.59	0.16	0.19	—	—	0.26	—
Canada:	Moosonee (col)	1.06	2.54	3.13	1.16	1.37	0.46	—	—	0.06
	Ernest Harmon AB (col)	1.27	1.67	2.22	1.73	0.67	0.37	—	—	0.14
	Goose Bay AB (col)	[b] —	—	—	—	—	—	—	—	—
Canal Zone:	Miraflores (col)	0.24	0.34	0.04	0.17	0.15	0.13	—	—	—
Chile:	Antofagasta (col)	0.02	0.02	0.02	0.02	0.02	0.01	—	—	[c]
	Puerto Montt (col)	0.10	0.36	0.27	0.32	0.24	—	—	0.33	0.52
	Punta Arenas (col)	0.03	0.10	0.02	—	—	0.12	—	—	0.25
	Santiago (pot)	0.02	0.03	0.05	0.21	—	0.03	[c]	[c]	—
	Santiago (col)	0.03	[b] —	0.44	0.13	0.42	—	—	—	—
Colombia:	Bogota (pot)	[d] 0.10	0.03	0.07	—	0.05	[c]	—	—	—
Costa Rica:	Turrialba (col)	0.11	0.37	0.25	0.31	0.16	0.05	—	—	0.11
Ecuador:	Guayaquil (col)	0.06	0.08	0.01	0.01	0.01	0.02	—	—	0.03
	Quito (col)	—	0.03	0.02	0.03	0.02	—	—	—	0.03
Greenland:	Thule (col)	0.13	0.07	0.19	0.63	0.13	—	—	—	0.04
Iceland:	Keflavik (col)	0.42	0.58	2.38	1.31	0.31	0.21	—	—	0.21
Mexico:	Mexico City (col)	—	—	—	—	—	—	—	—	0.01
Peru:	Lima (col)	0.02	0.02	0.03	0.05	—	—	—	0.05	—
	Lima (col)	0.01	0.03	0.02	0.05	0.06	0.02	—	—	0.02
Puerto Rico:	San Juan (col)	1.19	0.76	0.87	[c] 0.66	[c] 0.63	0.21	—	—	0.32
Venezuela:	Caracas (col)	0.17	0.17	0.29	0.51	0.15	0.10	—	0.03	0.07
	Caracas (col)	0.25	[c] 0.16	[c] 0.16	[c] 0.16	0.10	0.18	—	—	0.06

[a] Dash indicates data not available.
[b] Collection discontinued after February 1964.
[c] Zero or trace.
[d] Proportioned from originally consolidated data.

Table 3. Precipitation at 6 U.S. sites, HASL, April–December 1964

Sampling location	Precipitation, mm								
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
California, Palo Alto	1.02	13.2	13.7	(a)	4.57	(a)	22.1	81.6	131.1
New Jersey, Westwood	155.9	26.7	62.5	129.2	25.4	32.5	34.5	60.9	110.0
Oklahoma, Midwest City	53.4	95.0	17.3	24.4	95.0	88.9	28.9	156.7	17.0
Tennessee, Chattanooga	249.6	125.4	84.4	141.5	157.2	75.7	97.4	86.6	75.7
Washington, Seattle	33.8	35.3	78.0	(b)	24.9	47.2	16.5	113.9	113.9
Wisconsin, Appleton	66.1	135.1	38.4	140.7	61.7	99.8	7.87	54.1	14.0

[a] Zero or trace.
[b] Data not available.

Table 4. Radionuclide analyses of pot fallout samples at 6 U.S. sites, HASL, April–December 1964
Fission product and "tracer" radionuclides in monthly collections

(Deposition in nCi/m²)

Sampling location	Strontium-89									Strontium-90								
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
California, Palo Alto	<0.01	<0.05	<0.02	[a] —	—	—	0.20	0.65	0.08	0.05	0.22	0.12	0.03	0.08	0.01	0.10	0.33	0.49
New Jersey Westwood	—	—	—	—	—	—	0.05	0.26	—	2.58	0.86	2.39	1.07	0.43	0.11	0.31	0.34	—
Oklahoma, Midwest City	<0.67	<0.10	<0.05	—	—	—	0.69	1.59	0.01	1.33	2.54	0.73	0.46	0.54	0.42	0.36	0.46	0.04
Tennessee, Chattanooga	—	—	—	—	—	—	1.51	0.12	0.07	4.40	2.11	1.43	0.86	0.73	0.19	0.43	0.21	0.05
Washington, Seattle	<0.03	0.04	<0.04	<0.01	<0.05	<0.02	0.15	1.43	<0.02	1.54	1.87	1.15	0.68	0.33	0.30	0.18	0.80	0.62
Wisconsin, Appleton	—	—	—	—	—	—	0.19	1.79	0.06	1.35	2.46	0.77	1.19	0.71	0.65	0.38	0.45	0.16
	Cesium-137									Cerium-144								
California, Palo Alto	0.15	0.43	0.14	0.07	0.12	0.04	0.14	0.45	0.67	2.20	4.21	2.04	0.46	0.54	0.15	0.64	1.99	2.67
New Jersey, Westwood	4.48	1.36	4.14	1.86	0.63	0.29	0.46	0.45	—	29.2	8.54	24.0	10.3	3.00	1.85	0.95	1.88	—
Oklahoma, Midwest City	2.14	4.17	1.02	0.68	0.79	0.58	0.51	0.64	0.11	15.1	31.1	9.65	4.25	4.63	3.25	2.29	3.43	0.44
Tennessee, Chattanooga	9.66	3.26	2.52	1.27	0.80	0.34	0.45	0.16	0.13	64.9	26.4	13.0	0.97	10.9	lost	3.63	1.85	0.50
Washington, Seattle	1.89	2.40	1.73	1.03	0.53	0.57	0.29	0.88	0.91	14.7	12.3	9.73	6.02	3.00	2.70	1.67	3.82	3.44
Wisconsin, Appleton	2.37	4.17	1.31	2.28	1.20	1.14	0.30	0.70	0.26	16.8	29.0	0.74	13.6	0.74	0.64	1.72	3.17	1.06
	Zirconium-95									Manganese-54								
California, Palo Alto	0.05	0.09	0.08	0.04	0.02	0.02	0.11	0.20	0.05	0.08	0.15	0.07	0.04	0.02	<0.02	0.06	0.23	0.30
New Jersey, Westwood	1.87	0.34	0.52	0.23	0.13	<0.03	0.05	0.65	—	2.53	1.00	1.90	0.81	0.15	0.14	0.05	0.23	—
Oklahoma, Midwest City	0.21	0.60	0.10	0.08	0.08	0.07	0.36	0.32	0.03	1.07	2.60	0.58	0.36	0.31	0.36	0.24	0.34	0.05
Tennessee, Chattanooga	3.34	1.04	0.49	0.23	0.15	0.03	0.74	<0.01	<0.03	4.02	2.12	1.26	0.76	0.19	0.07	0.07	0.15	0.06
Washington, Seattle	0.77	0.51	0.32	0.15	0.03	0.05	0.12	0.34	0.09	1.49	1.67	1.08	0.67	0.29	0.23	0.15	0.37	0.33
Wisconsin, Appleton	0.98	0.97	0.26	0.29	0.15	0.11	0.43	0.29	0.04	1.20	2.85	0.73	0.88	0.33	<0.15	0.07	0.30	0.09

[a] Dash indicates data not available.

2. Fallout measurements in Canada October–December 1964

Department of National Health and Welfare
Ottawa, Canada

The monthly accumulated precipitation samples collected in conjunction with the Canadian air sampling program described earlier in this issue represent total fallout (wet and dry). The radiochemical analyses of these samples for October through December 1964 are given in table 5.

In general, the results show a continuation of the slow downward trend in fallout levels which has been evident in the past several months. A review and discussion of fallout levels in Canada during 1964 has been presented by Booth, *et al.* (*2*).

REFERENCES

(1) ONG, L. D. Y. Homogeneity between pot and ion exchange column strontium-90 measurements. Fallout Program Quarterly Summary Report, HASL–135:256–269. Office of Technical Services, Department of Commerce, Washington 25, D.C. (April 1, 1963). Price $4.00.

(2) BOOTH, A. H., E. R. SAMUELS, and V. K. MOHINDRA. Fallout levels in Canada during 1964. Data from Radiation Protection Program 3, No. 1:17–37 (January 1965), Department of National Health and Welfare, Ottawa, Canada.

Table 5. Radionuclide deposition (nCi/m²) in Canadian fallout, October–December 1964

Station	October					November					December [b]	
	^{89}Sr	^{90}Sr	^{137}Cs	^{95}Zr	^{140}Ba	^{89}Sr	^{90}Sr	^{137}Cs	^{95}Zr	^{140}Ba	^{90}Sr	^{137}Cs
Calgary	0.95	0.30	0.47	0.83	3.51	0.10	0.08	0.25	0.16	0.12	0.05	0.13
Coral Harbour	0.00	0.10	0.14	NA [a]	NA	0.42	0.32	0.44	NA	NA	0.02	0.04
Edmonton	1.60	0.16	0.28	NA	NA	0.12	0.20	0.30	NA	NA	0.11	0.22
Ft. Churchill	0.18	0.12	0.36	NA	NA	0.16	0.11	0.22	NA	NA	0.03	0.15
Ft. William	1.35	0.40	0.75	NA	NA	0.00	2.33	0.85	NA	NA	0.26	0.36
Fredericton	1.32	0.49	0.94	NA	NA	0.11	0.28	0.17	NA	NA	0.26	0.61
Goose Bay	0.49	0.29	0.51	NA	NA	0.25	0.16	0.10	NA	NA	0.11	0.32
Halifax	1.09	0.53	0.83	0.53	3.38	0.28	0.45	0.92	0.09	0.21	0.33	0.66
Inuvik	0.70	0.25	0.44	NA	NA	0.00	0.06	0.12	NA	NA	0.03	0.15
Montreal	0.90	0.35	0.67	0.32	2.21	0.39	0.29	0.61	0.07	0.26	0.39	0.70
Moosonee	0.48	0.33	0.70	NA	NA	0.29	0.29	0.28	NA	NA	0.10	0.16
Ottawa	0.88	0.21	0.25	NA	NA	0.61	0.32	0.52	NA	NA	0.28	0.29
Quebec	2.94	0.65	0.82	NA	NA	0.25	0.54	0.88	NA	NA	0.50	0.06
Regina	0.11	0.01	0.07	NA	NA	0.10	0.02	0.13	NA	NA	0.08	0.13
Resolute	0.74	0.20	0.46	NA	NA	0.41	0.51	0.85	NA	NA	0.32	0.24
St. John's, Nfld	2.34	0.63	0.83	NA	NA	0.25	0.50	0.45	NA	NA	0.62	0.86
Saskatoon	0.98	0.18	0.36	NA	NA	0.10	0.04	0.13	NA	NA	0.07	0.13
Sault Ste. Marie	0.39	0.45	0.79	NA	NA	0.48	0.58	1.15	NA	NA	0.55	0.85
Toronto	2.26	0.35	0.61	NA	NA	0.10	0.08	0.24	NA	NA	0.39	0.66
Vancouver	0.41	0.35	0.55	0.18	1.53	0.24	0.31	0.51	0.10	0.22	0.65	1.14
Whitehorse	0.15	0.14	0.21	NA	NA	0.15	0.19	0.33	NA	NA	0.02	0.04
Windsor	2.08	0.30	0.54	NA	NA	0.00	0.00	0.04	NA	NA	0.32	0.59
Winnipeg	1.99	0.19	0.38	1.19	7.53	0.15	0.13	0.19	0.04	0.14	0.06	0.16
Yellowknife	0.00	0.20	0.26	NA	NA	0.00	0.06	0.08	NA	NA	0.04	0.06

[a] NA indicates no analysis performed.
[b] Strontium-89, zirconium-95 and barium-140 levels not reported because of insignificantly low levels.

Section II—Milk and Food

MILK SURVEILLANCE

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the United States population and contains most of the radionuclides occurring in the environment which have been identified as biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to composite and analyze, and samples representative of milk consumption in any area can be readily obtained.

1. Pasteurized Milk Network May 1965

Division of Radiological Health and Division of Environmental Engineering and Food Protection, Public Health Service

The Public Health Service pasteurized milk surveillance program had its origin in a raw milk monitoring network (*1*) established by the Service in 1957. One of the primary objectives of this network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this study led to the activation of a pasteurized milk sampling program with stations selected to provide nationwide surveillance of milk production and consumption areas. The present Pasteurized Milk Network (PMN), which consists of 63 stations, has at least one station in every State, the Canal Zone, and Puerto Rico.

Sampling procedure

Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each station. The method specifies that each station's sample be composited of subsamples from each milk processing plant in proportion to the plant's average sales in the community served. At most stations the sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from 1 day's sales per month and was as representative of the community's supply as possible under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, samples were collected twice a week at nearly all stations and daily for short periods at selected stations. Since then the sampling frequency has been reduced to once a week.

Samples are preserved with formaldehyde and sent to the PHS Southwestern (SWRHL), Southeastern (SERHL), or Northeastern (NERHL) Radiological Health Laboratories for analysis. Gamma analyses for iodine–131 are made within 3 to 6 days after sample collection, and any results exceeding 100 pCi/liter are immediately telephoned to appropriate State health officials for possible public health action. Analytical results are normally available 6 to 7 weeks after weekly samples are received by the laboratories; publication in *RHD* follows 3 to 4 months after the monthly samples are composited for analysis.

Analytical procedures

Iodine–131, cesium–137, and barium–140 concentrations are determined by gamma scintillation spectrometry.[1] After the weekly samples are gamma scanned, samples from two consecutive weeks are composited and analyzed radiochemically to determine strontium–89

[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium–140 analysis.

and strontium–90. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation on a percentage basis is relatively high. The variation depends upon such factors as the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclides, and the background count. For milk samples, counting times of 50 minutes for gamma spectrometry and 30 to 50 minutes for beta determinations are used. Table 1 shows the approximate analytical error (including counting error) associated with determinations of radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses.

Table 1. Analytical errors associated with determinations of radionuclides concentrations in milk

Nuclide	Estimated concentration (pCi/liter)	Error [a] (pCi/liter)	Estimated concentration (pCi/liter)	Error [a] (percent of concentration)
Iodine-131	<100	10	100 or greater	10
Barium-140	<100	10	100 or greater	10
Cesium-137	<100	10	100 or greater	10
Strontium-89	<50	5	50 or greater	10
Strontium-90	<20	2	20 or greater	10

[a] Two standard deviations

The minimum detectable concentration is defined as the measured concentration equal to the two-standard deviation analytical error. Accordingly, the minimum detectable concentrations in units of pCi/liter are: strontium–89, 5; strontium–90, 2; cesium–137, 10; barium–140, 10; and iodine–131, 10. At these levels and below, the counting error comprises nearly all of the analytical error.

Calcium analyses at SERHL are done by an ion exchange and permanganate titration method, while at NERHL and SWRHL an ethylenediaminetetraacetic acid (EDTA) method is used. Stable potassium concentrations are estimated from the potassium–40 concentrations[2] determined from the gamma spectrum.

Data presentation

Table 2 presents summaries of the analyses for May 1965 (actual reporting period is April 25, 1965, to May 29, 1965). Radionuclide values reported by a laboratory as being below the minimum detectable concentration have been averaged by using one-half the minimum detectable value. The averaging procedure was modified for iodine–131 and barium–140 in October 1963, when nondetectable concentrations of these radionuclides were considered zero. A similar procedure is used for the network average.

Figures 1 and 2 are isogram maps showing the estimated strontium–90 and cesium–137 concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station. The isograms were developed by arbitrary interpolation between values for the individual stations.

[2] The conversion factor is 1.18 milligrams K/pCi^{40}K.

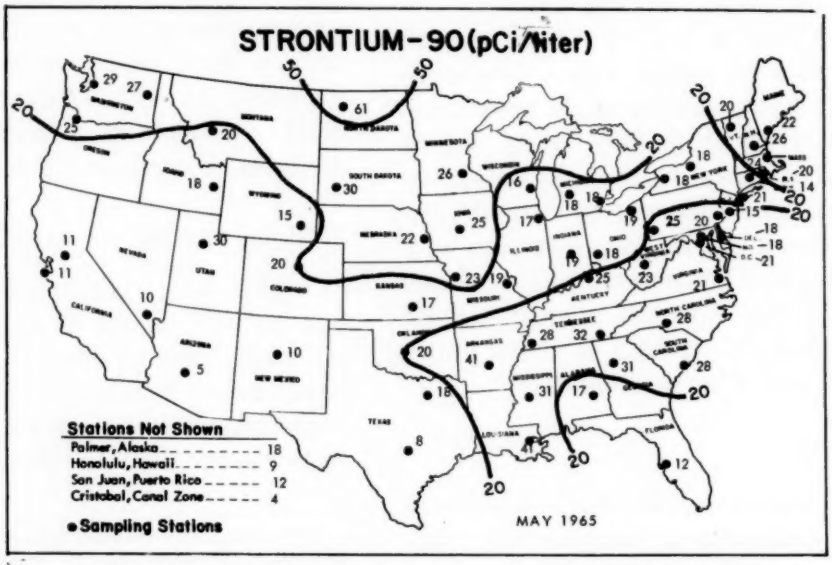

Figure 1. Strontium–90 concentrations in pasteurized milk, May 1965

Table 2. Average concentrations of stable elements and radionuclides in pasteurized milk, first quarter 1965 and May 1965

Sampling locations		Calcium (g/liter)		Strontium-89 (pCi/liter)		Strontium-90 (pCi/liter)		Cesium-137 (pCi/liter)		Iodine-131 (pCi/liter)	
		First quarter	Average for May	First quarter	Average for May	First quarter	Average for May	First quarter	Average for May	First quarter	Average for May
Ala:	Montgomery	1.19	1.19	<5	<5	19	17	55	50	0	0
Alaska:	Palmer	1.18	1.25	<5	<5	17	18	60	70	0	10
Ariz:	Phoenix	1.20	1.23	<5	<5	6	5	25	20	0	0
Ark:	Little Rock	1.18	1.15	<5	<5	34	41	70	65	0	0
Calif:	Sacramento	1.26	1.18	<5	<5	7	10	35	35	0	10
	San Francisco	1.27	1.29	<5	<5	8	11	35	35	0	0
C. Z:	Cristobal	1.14	1.08	<5	<5	5	4	40	35	0	0
Colo:	Denver	1.27	1.38	<5	<5	18	20	70	70	0	0
Conn:	Hartford	1.12	1.10	<5	<5	16	14	90	80	0	0
Del:	Wilmington	1.15	1.15	<5	<5	19	18	80	65	0	0
D. C:	Washington	1.17	1.16	<5	<5	17	18	60	50	0	10
Fla:	Tampa	1.18	1.18	<5	<5	13	12	160	185	0	0
Ga:	Atlanta	1.19	1.14	<5	<5	26	31	90	85	0	0
Hawaii:	Honolulu	1.18	1.22	<5	<5	11	9	65	60	0	0
Idaho:	Idaho Falls	1.21	1.24	<5	<5	21	18	110	100	0	0
Ill:	Chicago	1.12	1.15	<5	<5	17	17	90	80	0	0
Ind:	Indianapolis	1.19	1.16	<5	<5	17	19	75	55	0	0
Iowa:	Des Moines	1.20	1.27	<5	5	22	25	60	60	0	30
Kans:	Wichita	1.24	1.27	<5	<5	18	17	55	40	0	0
Ky:	Louisville	1.17	1.16	<5	<5	22	25	60	40	0	0
La:	New Orleans	1.23	1.21	5	<5	43	41	80	75	0	0
Maine:	Portland	1.14	1.12	<5	<5	22	22	135	130	0	0
Md:	Baltimore	1.16	1.15	<5	<5	18	21	65	60	0	0
Mass:	Boston	1.16	1.13	<5	<5	23	24	140	130	0	0
Mich:	Detroit	1.15	1.15	<5	<5	16	18	85	80	0	0
	Grand Rapids	1.18	1.17	<5	<5	19	18	90	85	0	0
Minn:	Minneapolis	1.22	1.30	<5	10	26	26	90	100	0	10
Miss:	Jackson	1.25	1.17	<5	<5	34	31	60	50	0	0
Mo:	Kansas City	1.22	1.26	<5	5	22	2	60	45	0	40
	St. Louis	1.25	1.28	<5	<5	17	19	50	45	0	10
Mont:	Helena	1.25	1.34	<5	<5	18	20	95	90	0	20
Nebr:	Omaha	1.25	1.21	<5	<5	18	22	50	50	0	10
Nev:	Las Vegas	1.20	1.33	<5	<5	9	10	40	45	0	0
N. H:	Manchester	1.16	1.13	<5	<5	24	26	155	165	0	0
N. J:	Trenton	1.13	1.12	<5	<5	16	15	80	70	0	0
N. Mex:	Albuquerque	1.22	1.25	<5	<5	12	10	45	35	0	0
N. Y:	Buffalo	1.11	1.09	<5	<5	17	18	110	105	0	0
	New York	1.12	1.13	<5	<5	19	21	105	100	0	0
	Syracuse	1.11	1.10	<5	<5	16	18	95	85	0	0
N. C:	Charlotte	1.20	1.18	<5	<5	29	28	65	65	0	0
N. Dak:	Minot	1.21	1.26	<5	<5	52	61	125	125	0	0
Ohio:	Cincinnati	1.16	1.13	<5	<5	17	18	70	45	0	0
	Cleveland	1.16	1.12	<5	<5	18	19	95	75	0	10
Okla:	Oklahoma City	1.18	1.13	<5	<5	21	20	55	45	0	0
Ore:	Portland	1.28	1.33	<5	5	20	25	100	90	0	0
Pa:	Philadelphia	1.16	1.14	<5	<5	17	20	80	65	0	0
	Pittsburgh	1.16	1.12	<5	<5	24	25	105	95	0	0
P. R:	San Juan	1.14	1.09	<5	<5	12	12	50	45	0	0
R. I:	Providence	1.16	1.11	<5	<5	19	20	100	100	0	0
S. C:	Charleston	1.20	1.18	<5	<5	30	28	85	115	0	0
S. Dak:	Rapid City	1.03	1.10	<5	10	28	30	135	110	0	0
Tenn:	Chattanooga	1.22	1.22	<5	<5	31	32	70	60	0	0
	Memphis	1.20	1.16	<5	<5	26	28	45	40	0	0
Tex:	Austin	1.15	1.12	<5	<5	9	8	35	30	0	0
	Dallas	1.19	1.17	<5	<5	18	18	45	40	0	0
Utah:	Salt Lake City	1.30	1.44	<5	<5	25	30	125	130	0	0
Vt:	Burlington	1.12	1.13	<5	<5	21	20	120	110	0	0
Va:	Norfolk	1.19	1.17	<5	<5	21	21	60	65	0	10
Wash:	Seattle	1.26	1.31	<5	<5	23	29	90	110	0	0
	Spokane	1.28	1.29	<5	<5	26	27	100	95	0	0
W. Va:	Charleston	1.18	1.14	<5	5	16	23	50	40	0	10
Wis:	Milwaukee	1.20	1.16	<5	<5	14	16	100	95	0	10
Wyo:	Laramie	1.25	1.25	<5	<5	13	15	65	65	0	0
Network average		1.19	1.19	<5	<5	19.9	21.0	79	74	0	3

[a] Results of barium-140 analyses all zero.

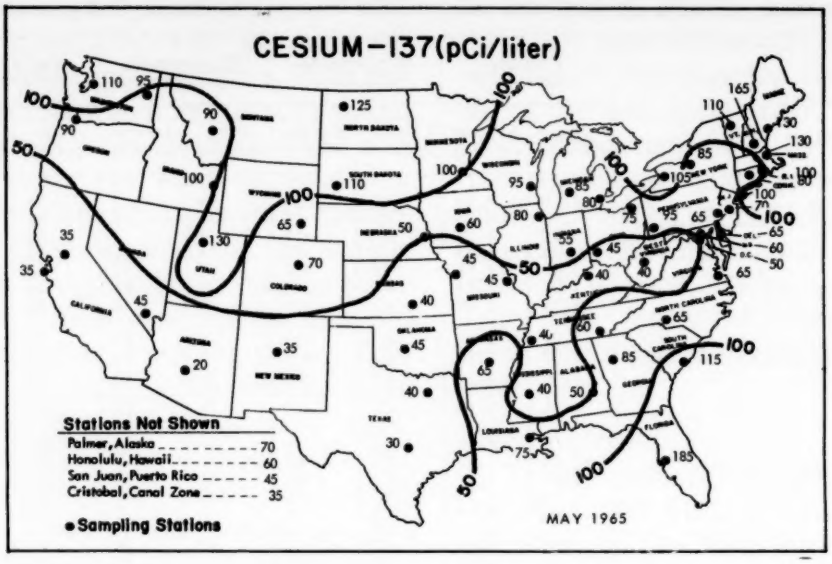

Figure 2. Cesium–137 concentrations in pasteurized milk, May 1965

The distribution of monthly average strontium–90 concentrations as observed in pasteurized milk for December 1964 through May 1965 is presented in table 3. The maximum monthly average concentration of strontium–90 was 61 pCi/liter, observed at Minot, North Dakota. This level is within the lower half of Range II as defined by the Federal Radiation Council (20–200 pCi/liter). The average monthly strontium–90 concentrations in pasteurized milk from selected cities in the sampling program are presented in figure 3.

Table 3. Frequency distribution of strontium-90 concentrations in milk at PMN stations, December 1964-May 1965, and May 1964

Strontium-90 (pCi/liter)	Number of stations						
	1964	1965					1964
	Dec	Jan	Feb	Mar	Apr	May	May
Under 10	8	6	3	5	5	4	3
10–19	29	32	31	29	23	26	8
20–29	20	19	22	21	27	25	20
30–39	4	4	5	6	5	5	20
40–49	2	1	2	1	2	2	6
50–59	0	1	0	1	0	0	4
60–69	0	0	0	0	1	1	1
70–79	0	0	0	0	0	0	1

The Network average cesium–137 concentration in milk for May 1965 was 74 pCi/liter as compared to 82 pCi/liter in April 1965. The maximum monthly average concentration in pasteurized milk was 185 pCi/liter, observed at Tampa, Florida. The distribution of monthly average cesium–137 concentrations in milk for December 1964 through May 1965 is presented in table 4.

Table 4. Frequency distribution of cesium-137 concentrations in milk at PMN stations, December 1964–May 1965, and May 1964

Cesium-137 (pCi/liter)	Number of stations						
	1964	1965					1964
	Dec	Jan	Feb	Mar	Apr	May	May
Under 50	9	11	8	9	7	17	2
50–99	38	38	38	36	35	31	16
100–149	14	12	15	16	18	13	17
150–199	2	2	2	2	3	2	23
200–249	0	0	0	0	0	0	3
250–299	0	0	0	0	0	0	2

The decrease in radionuclide concentrations in milk observed during January through May 1965 can be expected to continue in the absence of atmospheric nuclear testing. This trend is in agreement with concentrations observed from March 1960 through 1964 (*2*, *3*).

Perusal of 1965 sampling results indicates no evidence of the anticipated "spring rise" in strontium–90 or cesium–137 concentrations in pasteurized milk.

During May 1965, iodine–131 was observed in weekly milk samples at 19 sampling stations (table 5). The maximum concentration observed was 220 pCi/liter on May 28, 1965. The levels of iodine–131 observed were such that only 13 stations exhibited monthly averages greater than the detection limit of 10 pCi/liter. The highest monthly average, 40 pCi/liter, observed in Kansas City, Missouri, was within Range II as defined by the Federal Radiation Council (10–100 pCi/liter). The presence of iodine–131 in pasteurized milk during May 1965 is presumed a consequence of the mainland China atmospheric nuclear test of May 13, 1965 (10:00 p.m. EDT).

Table 5. Occurrence of iodine-131 in pasteurized milk, May 1965

(Concentration in pCi/liter)

Sampling location		May							
		24	25	26	27	28	29	30	31
Alaska:	Palmer			30					
Calif:	Sacramento					40			
D.C.:	Washington				40				
Hawaii:	Honolulu	20							
Ill:	Chicago		20						
Iowa:	Des Moines				170				
Kans:	Wichita								30
Minn:	Minneapolis		60						
Mo:	Kansas City					220			
	St. Louis				50				
Nebr:	Omaha					70			
N.Y:	Buffalo					20			
N. Dak:	Minot								30
Ohio:	Cleveland					60			
S. Dak:	Rapid City	20							
Tex:	Dallas								20
Va:	Norfolk					40			
W. Va:	Charleston					30			
Wis:	Milwaukee		50						

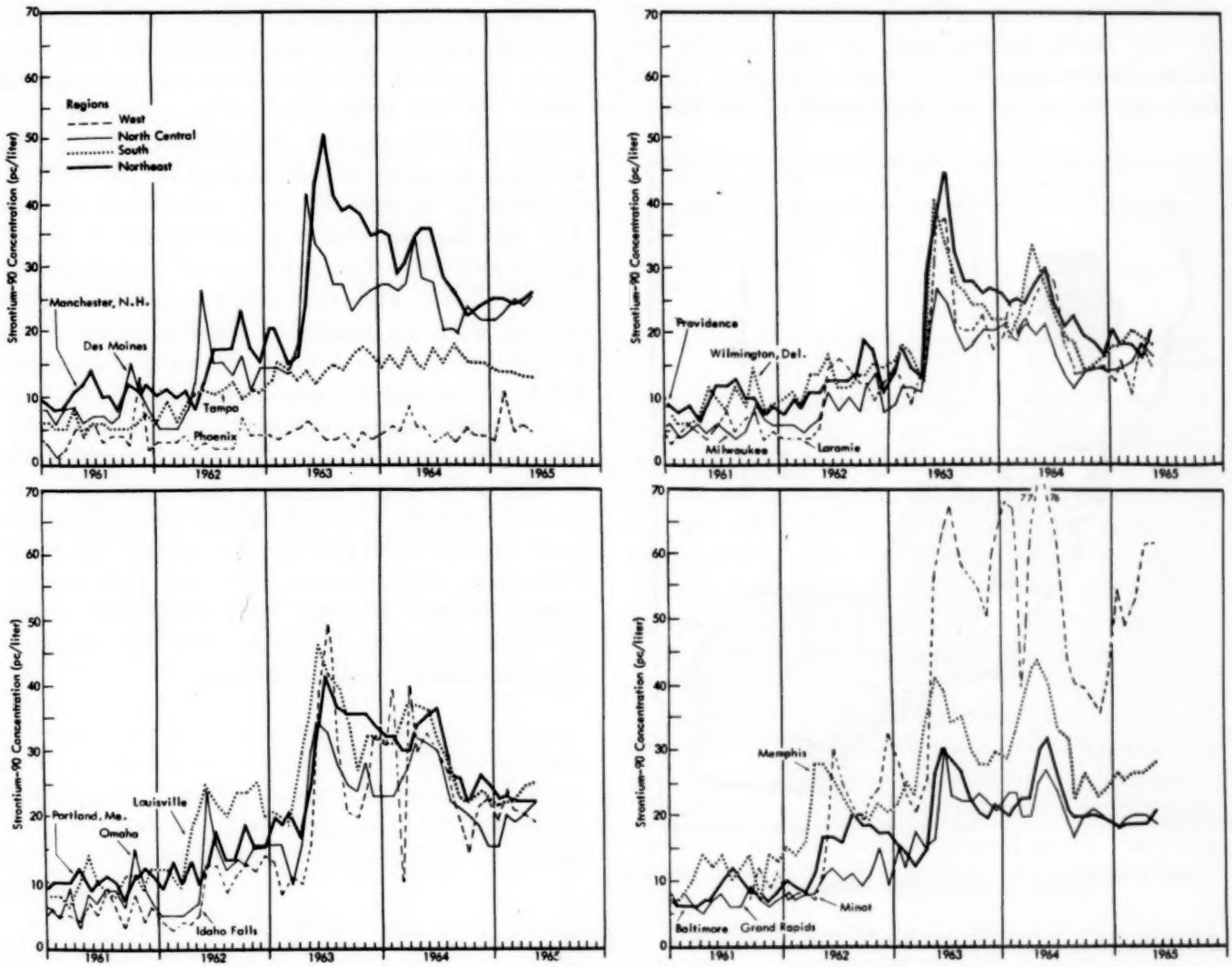

Figure 3. Strontium–90 concentrations in pasteurized milk, 1961—May 1965

2. California Milk Network January–March 1965

State of California
Department of Public Health

Surveillance of specific radionuclides in milk is one phase of California's Department of Public Health program of radiation control. This milk monitoring function has been conducted at 8 milksheds since January 1960 by the Department's Bureau of Radiological Health, a constituent of the Division of Environmental Sanitation. Since the addition of the Del Norte and Mendocino milksheds to the program in March 1962, weekly, biweekly, or monthly sampling of pasteurized milk has been conducted at 10 major milksheds (see figure 4). The original sampling locations were chosen by the State Department of Agriculture as being representative of milk consumed by a high percentage of the population of the State.

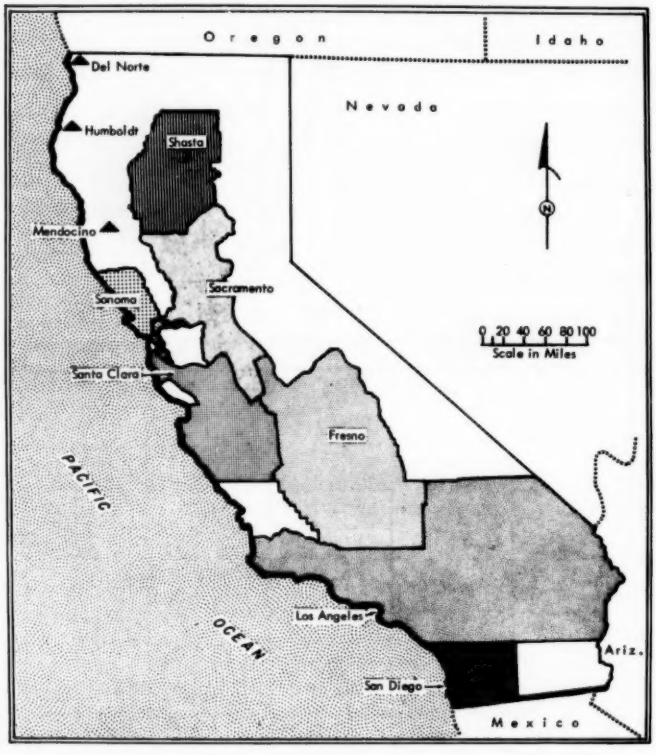

Figure 4. California milksheds

Analytical procedures

After precipitation of the proteins with trichloroacetic acid, strontium is precipitated, scavenged, and beta counted in a low-background counter. After a two-week ingrowth period, the yttrium–90 is precipitated from the radiostrontium fraction and beta counted. Strontium–90 is determined from the yttrium–90 results; strontium–89 is determined by difference.

Potassium–40, iodine–131, cesium–137 and barium–140 in whole fluid milk are determined by gamma-scintillation spectroscopy using a sodium iodide crystal. A normal counting time of 100 minutes is used. The stable potassium content of milk (g/liter) may be estimated by multiplying the potassium–40 concentration (pCi/liter) by 1.18×10^{-3}. A more complete description of the laboratory equipment and procedures has been published earlier (*4*).

Results

The monthly calcium and radionuclide concentrations in California pasteurized milk are given in table 6 for the period January–March 1965. As has been previously noted the Del Norte sample differs significantly from the network average. A description of the various California milksheds was presented earlier (*5*). Radiostrontium was discussed in detail previously (*6*). The presence of strontium–89 in Del Norte and Humboldt counties is consistent with an apparent deposition of fresh fission products during October–November 1964, which was discussed previously (*6*).

Network average strontium–90 and cesium–137 concentrations are presented graphically in figure 5. Superimposed upon normal seasonal variations is a decreasing trend since the peak which occurred in the spring of 1963. This peak resulted from 1961 and 1962 atmospheric nuclear testing. This downward trend can be expected to continue with the cessation of atmospheric nuclear testing.

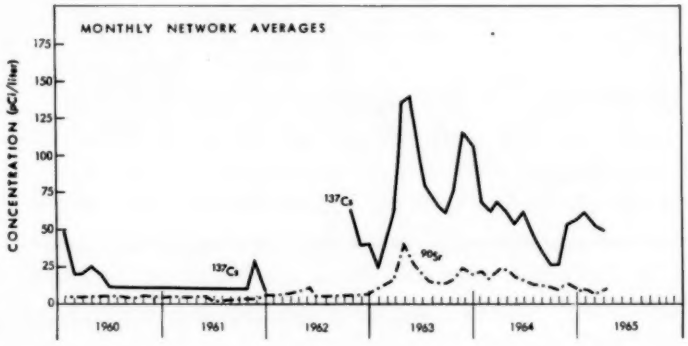

Figure 5. Radionuclides in California pasteurized milk

Table 6. Stable elements and radionuclides in California milk,[a] January–March 1965

Element and month	Del Norte	Fresno	Humboldt	Los Angeles	Mendocino	Sacramento	San Diego	Santa Clara	Shasta	Sonoma	Average
Calcium (g/liter)											
January	1.34	1.31	1.23	1.12	1.15	1.25	1.19	1.17	1.38	1.10	1.22
February	1.31	1.26	1.25	1.13	1.25	1.26	1.17	1.18	1.18	1.23	1.22
March	1.34	1.20	1.21	1.17	1.12	1.26	1.16	1.20	1.18	1.18	1.20
Potassium-40 (pCi/liter)											
January	1,130	1,170	1,180	1,190	1,400	1,200	1,280	1,200	1,180	1,170	1,210
February	1,140	1,260	1,200	1,230	1,280	1,220	1,250	1,450	1,180	1,340	1,260
March	1,130	1,160	1,200	1,160	1,310	1,230	1,290	1,370	1,200	1,170	1,220
Strontium-89 (pCi/liter)											
January	17	NA	ND	NA	NA	NA	NA	NA	NA	NA	—
February	10	NA	ND	NA	NA	NA	NA	NA	NA	NA	—
March	8	NA	5.3	NA	NA	NA	NA	NA	NA	NA	—
Strontium-90 (pCi/liter)											
January	54	5.6	10.8	4.4	6.3	6.1	5.2	4.9	9.0	9.8	11.6
February	41	5.7	12.8	5.4	8.7	5.6	4.2	4.4	8.3	11.8	10.7
March	39	8.5	13.0	4.1	10.6	8.4	4.3	8.5	9.5	10.4	11.6
Cesium-137 (pCi/liter)											
January	254	33	65	26	28	37	27	24	47	41	58
February	165	37	69	33	40	36	23	38	41	26	50
March	106	38	55	27	33	42	21	37	44	60	46

[a] No significant amounts of iodine-131 or barium-lanthanum-140 in samples for this period were found.
Key to symbols: NA—indicates no analysis.
ND—indicates below detectable level.

Previous coverage in *Radiological Health Data:*

Period	Issue
July–September 1963	*March 1964*
October–December 1963	*June 1964*
January–March 1964	*September 1964*
April–June 1964	*December 1964*
July–September 1964	*March 1965*
October–December 1964	*June 1965*

3. Michigan Milk Network November 1962—December 1964

Division of Occupational Health
Michigan Department of Health

The Michigan Department of Health began sampling pasteurized milk for radionuclide analyses in November 1962. Under this program, weekly pasteurized milk samples are collected in the seven major milk producing areas in the State: Charleviox, Detroit, Grand Rapids, Lansing, Marquette, Monroe, and Saginaw (figure 6). Dairy samples within each area are composited in proportion to sales volume.

Analytical procedures

The resultant samples are analyzed weekly for strontium–90, iodine–131, cesium–137, potassium–40, and barium–lanthanum–140. The analytical procedure for strontium–90 is based upon ion exchange methods. Cations are eluted from the ion exchange resin with a sodium chloride solution. Subsequently calcium and strontium are separated using a nitric acid method. The strontium is scavenged from the rare earths and set aside for a two-week yttrium–90 ingrowth. The yttrium–90 is then separated and counted in a low-background beta counter, after which the strontium–90 is calculated.

Iodine–131, cesium–137, potassium–40, and barium–lanthanum–140 concentrations are determined by gamma-scintillation spectroscopy. The counting system consists of a 4 x 4-inch sodium iodide (thallium-activated) crystal detector and a 400–channel pulse-height analyzer.

The minimum levels of detectability are as follows: strontium–90, 9 picocuries per liter; cesium–137, 5 picocuries per liter; iodine–131, 14 picocuries per liter; potassium–40, 80 picocuries per liter; and barium–lanthanum–140, 4 picocuries per liter.

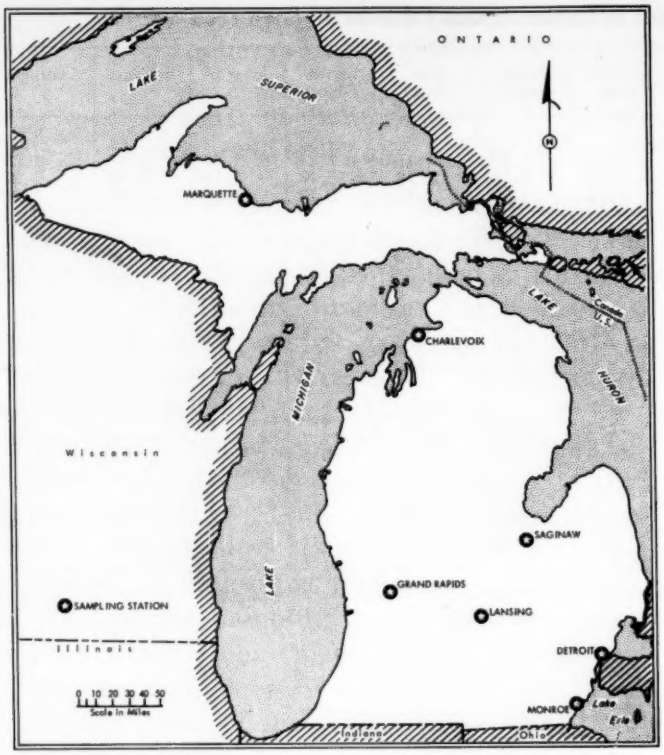

Figure 6. Michigan milk sampling stations

Results and discussion

Tables 7 through 13 present the monthly average radionuclide concentrations in Michigan pasteurized milk for the period November 1962 through December 1964. The results are given for the seven major milk producing areas in the State.

During this period iodine–131 and barium–lanthanum–140 concentrations in general remained below detectable levels.

In order to visualize general trends in strontium–90 and cesium–137, monthly average concentrations are presented graphically in figure 7. Strontium–90 and cesium–137 concentrations increased in the spring of 1963 following atmospheric nuclear testing. Strontium–90 concentrations reached a peak in the spring of 1964. Cesium–137 concentrations reached a peak in the summer of 1963 and have decreased since that time.

Table 7. Radionuclides in Charlevoix milk, November 1962-December 1964

Month and year	Radionuclide concentrations, pCi/liter				
	Potassium-40	Strontium-90	Iodine-131	Cesium-137	Barium-lanthanum-140
1962					
November	NS	NS	NS	NS	NS
December	NS	NS	NS	NS	NS
1963					
January	1,210	NA	<20	96	0
February	1,360	NA	<20	73	0
March	1,320	NA	<20	82	1
April	1,300	NA	<20	81	1
May	1,320	NA	<20	83	1
June	1,260	NA	<20	148	1
July	1,280	21	<20	189	1
August	1,270	16	<20	195	2
September	1,280	20	<20	172	5
October	1,270	15	<20	146	8
November	1,260	17	<20	155	8
December	1,360	19	<20	170	3
1964					
January	1,280	20	<20	167	5
February	1,330	25	<20	166	1
March	1,290	23	<20	168	4
April	1,340	21	<20	174	2
May	1,310	24	<20	150	2
June	1,300	25	<20	153	1
July	1,300	20	<20	163	3
August	1,340	18	<20	95	1
September	1,210	18	[a] <14	86	2
October	NS	NS	NS	NS	NS
November	1,360	19	<14	90	0
December	1,360	NA	<14	86	0

[a] Minimum detectable level reduced by recalibration of instrument in September 1964.
Key to symbols: NS—no sample collected
NA—no analyses

Table 8. Radionuclides in Detroit milk, November 1962–December 1964

Month and year	Radionuclide concentrations, pCi/liter				
	Potassium-40	Strontium-90	Iodine-131	Cesium-137	Barium-lanthanum-140
1962					
November	1,240	NA	60	70	8
December	1,300	NA	24	72	1
1963					
January	1,310	NA	<20	73	0
February	1,330	NA	<20	80	0
March	1,360	NA	<20	69	5
April	1,310	NA	<20	73	0
May	1,320	NA	<20	85	1
June	1,230	NA	<20	112	2
July	1,330	14	<20	120	1
August	1,310	14	<20	145	0
September	1,280	13	<20	125	7
October	1,280	10	<20	108	3
November	1,330	11	<20	113	5
December	1,340	13	<20	125	1
1964					
January	1,310	16	<20	128	2
February	1,270	19	<20	126	2
March	1,360	18	<20	126	1
April	1,240	17	<20	123	3
May	1,280	19	<20	120	2
June	1,330	16	<20	112	1
July	1,280	17	<20	120	1
August	1,310	17	<20	74	1
September	1,200	14	[a] <14	55	1
October	NS	NS	NS	NS	NS
November	1,330	12	<14	60	0
December	1,360	NA	<14	67	0

[a] Minimum detectable level reduced by recalibration of instrument in September 1964.
Key to symbols: NS—no sample collected
NA—no analyses

Table 9. Radionuclides in Grand Rapids milk, November 1962–December 1964

Month and year	Radionuclide concentrations, pCi/liter				
	Potassium-40	Strontium-90	Iodine-131	Cesium-137	Barium-lanthanum-140
1962					
November	NS	NS	NS	NS	NS
December	1,320	NA	<20	64	1
1963					
January	1,300	NA	<20	71	0
February	1,310	NA	<20	65	1
March	1,350	NA	<20	69	4
April	1,320	NA	<20	66	1
May	1,400	NA	<20	85	0
June	1,300	NA	<20	113	1
July	1,260	22	<20	139	1
August	1,300	16	<20	146	0
September	1,330	13	<20	128	4
October	1,290	13	<20	124	6
November	1,280	12	<20	125	5
December	1,330	14	<20	137	1
1964					
January	1,330	19	<20	134	3
February	1,290	18	<20	137	2
March	1,320	18	<20	139	2
April	1,310	18	<20	134	2
May	1,310	22	<20	133	0
June	1,280	21	<20	128	2
July	1,270	20	<20	118	3
August	1,350	16	<20	84	1
September	1,180	17	[a] <14	66	1
October	NS	NS	NS	NS	NS
November	1,370	18	<14	70	1
December	1,360	NA	<14	71	0

[a] Minimum detectable level reduced by recalibration of instrument in September 1964.
Key to symbols: NS—no sample collected
NA—no analyses

Table 10. Radionuclides in Lansing milk, November 1962-December 1964

Month and year	Radionuclide concentrations, pCi/liter				
	Potassium-40	Strontium-90	Iodine-131	Cesium-137	Barium-lanthanum-140
1962					
November	1,250	NA	48	61	4
December	1,300	NA	<20	61	2
1963					
January	1,350	NA	<20	61	1
February	1,390	NA	<20	57	0
March	1,310	NA	<20	61	1
April	1,350	NA	<20	59	1
May	1,300	NA	<20	81	3
June	1,310	NA	<20	107	0
July	1,290	14	<20	114	3
August	1,220	20	<20	124	6
September	1,330	12	<20	109	2
October	1,330	12	<20	99	8
November	1,300	10	<20	112	2
December	1,330	14	<20	113	5
1964					
January	1,280	15	<20	121	3
February	1,280	17	<20	118	4
March	1,330	21	<20	123	1
April	1,340	18	<20	121	2
May	1,300	19	<20	114	1
June	1,240	20	<20	108	3
July	1,310	15	<20	114	1
August	1,340	17	<20	73	1
September	1,210	15	[a] <14	53	1
October	NS	NS	NS	NS	NS
November	1,350	17	<14	59	1
December	1,410	NA	<14	68	0

[a] Minimum detectable level reduced by recalibration of instrument in September 1964.
Key to symbols: NS—no sample collected
NA—no analyses

Table 11. Radionuclides in Marquette milk, November 1962-December 1964

Month and year	Radionuclide concentrations, pCi/liter				
	Potassium-40	Strontium-90	Iodine-131	Cesium-137	Barium-lanthanum-140
1962					
November	NS	NS	NS	NS	NS
December	NS	NS	NS	NS	NS
1963					
January	1,290	NA	<20	110	3
February	1,340	NA	<20	149	0
March	NS	NS	NS	NS	NS
April	1,340	NA	<20	137	1
May	1,330	NA	<20	158	1
June	1,370	18	<20	257	0
July	1,270	14	<20	368	5
August	1,290	27	<20	311	6
September	1,250	30	<20	295	8
October	1,240	18	<20	233	6
November	1,320	28	<20	232	10
December	1,340	35	<20	254	7
1964					
January	1,350	37	<20	263	5
February	1,310	40	<20	257	7
March	1,330	43	<20	267	5
April	1,340	22	<20	274	0
May	1,330	41	<20	249	1
June	1,310	NA	<20	249	5
July	1,320	38	<20	220	6
August	1,300	33	<20	149	2
September	1,180	30	[a] <14	126	8
October	NS	NS	NS	NS	NS
November	1,360	NA	20	128	8
December	1,340	NA	<14	150	1

[a] Minimum detectable level reduced by recalibration of instrument in September 1964.
Key to symbols: NS—no sample collected
NA—no analyses

Table 12. Radionuclides in Monroe milk, November 1962–December 1964

Month and year	Radionuclide concentrations, pCi/liter				
	Potassium-40	Strontium-90	Iodine-131	Cesium-137	Barium-lanthanum-140
1962					
November	NS	NS	NS	NS	NS
December	NS	NS	NS	NS	NS
1963					
January	1,250	NA	<20	50	1
February	1,280	NA	<20	53	1
March	1,320	NA	<20	54	1
April	1,320	NA	<20	55	1
May	1,310	NA	<20	63	1
June	1,320	NA	<20	86	0
July	1,290	11	<20	87	1
August	1,230	16	<20	85	2
September	1,250	7	<20	65	3
October	1,250	8	<20	69	3
November	1,310	7	<20	77	9
December	1,320	9	<20	79	1
1964					
January	1,330	15	<20	93	2
February	1,260	11	<20	84	1
March	1,270	11	<20	84	1
April	1,280	12	<20	85	1
May	1,270	14	<20	87	0
June	1,270	16	<20	102	2
July	NS	NS	NS	NS	NS
August	1,350	12	<20	56	0
September	1,230	14	[a] <14	43	1
October	NS	NS	NS	NS	NS
November	1,340	13	15	47	0
December	1,370	NA	<14	50	0

[a] Minimum detectable level reduced by recalibration of instrument in September 1964.
Key to symbols: NS—no sample collected
NA—no analyses

Table 13. Radionuclides in Saginaw milk, November 1962–December 1964

Month and year	Radionuclide concentrations, pCi/liter				
	Potassium-40	Strontium-90	Iodine-131	Cesium-137	Barium-lanthanum-140
1962					
November	NS	NS	NS	NS	NS
December	NS	NS	NS	NS	NS
1963					
January	1,240	NA	<20	64	1
February	1,240	NA	<20	71	3
March	1,370	NA	<20	68	0
April	1,300	NA	<20	60	2
May	1,320	NA	<20	71	0
June	1,330	NA	<20	109	1
July	1,330	15	<20	132	1
August	1,350	11	<20	143	3
September	1,290	13	<20	134	3
October	1,300	12	<20	122	5
November	1,280	12	<20	134	5
December	1,310	12	<20	143	2
1964					
January	1,330	15	<20	144	1
February	1,300	17	<20	144	2
March	1,290	19	<20	151	2
April	1,320	18	<30	144	0
May	1,280	18	<20	136	0
June	1,310	17	<20	125	0
July	1,330	15	<20	109	1
August	1,340	15	<20	78	0
September	1,170	13	[a] <14	55	1
October	NS	NS	NS	NS	NS
November	1,340	12	<20	58	0
December	1,360	NA	<14	68	0

[a] Minimum detectable level reduced by recalibration of instrument in September 1964.
Key to symbols: NS—no sample collected
NA—no analyses

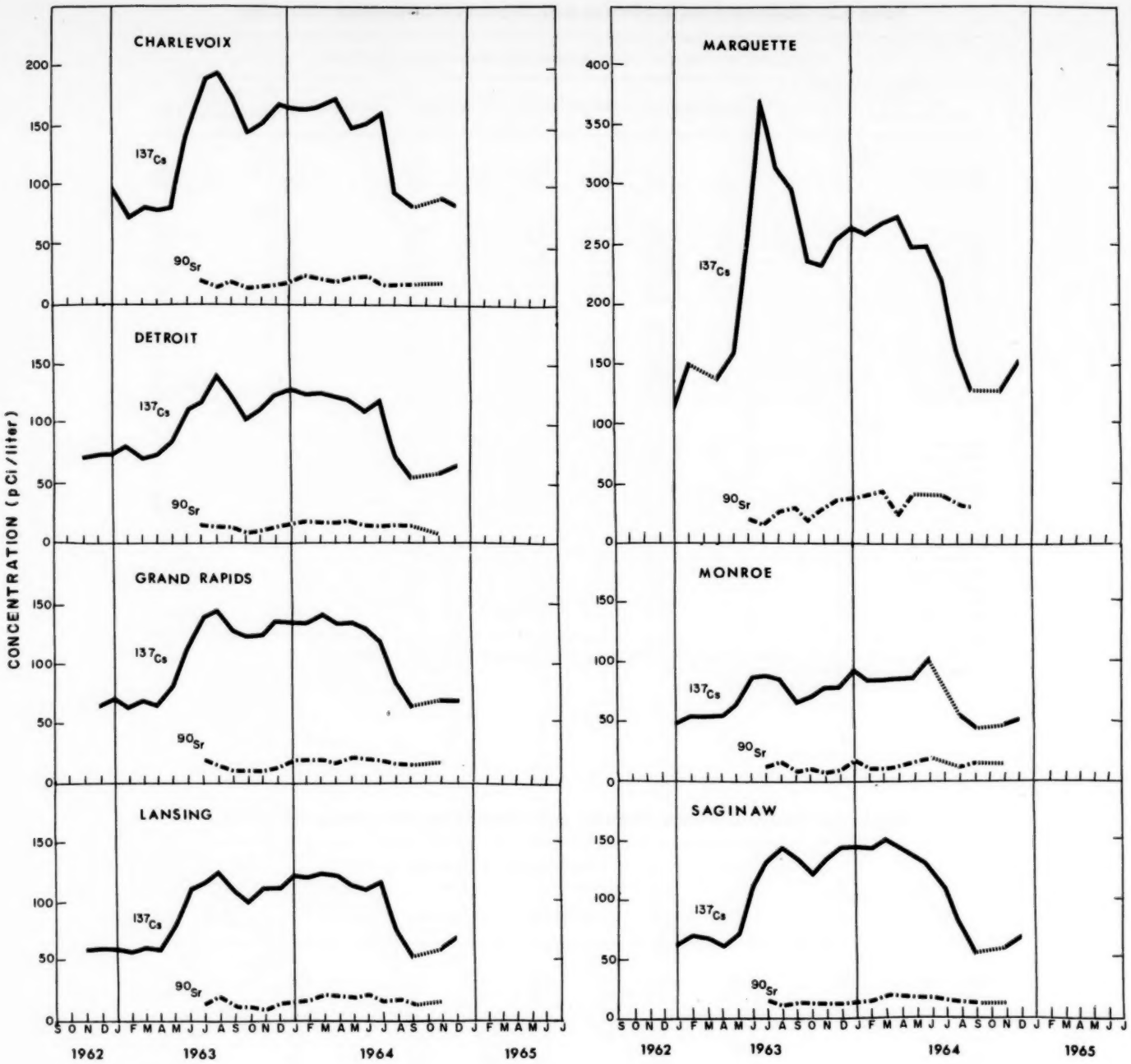

Figure 7. Monthly average concentrations of strontium–90 and cesium–137 in Michigan milk, 1962–1964

4. Pennsylvania Milk Network January–March 1965

Bureau of Environmental Health
Pennsylvania Department of Health

Samples of pasteurized milk are routinely collected from 10 major milk consumption areas throughout Pennsylvania (figure 8). Two samples per week are collected in Philadelphia and Pittsburgh, while weekly composite samples are collected from the other eight stations. At each sampling location subsamples are collected from the major duties supplying the area and are composited in proportion to the amount of milk processed by each dairy. This composite is then sent to the Radiation Laboratory of the Division of Occupational Health in Harrisburg where the weekly samples are combined for monthly analyses. Strontium–90 analyses have been carried out since April 1963.

The chemical separation technique for strontium–90 is essentially an ion exchange method described by Porter, *et al.* (*7*). One liter of milk is passed through an ion exchange column; yttrium–90 is eluted from the resin and is counted in an automatic low-background proportional counter.

The January to March average strontium–90 levels in pasteurized milk are shown in table 14 and presented together with earlier network results in figure 9.

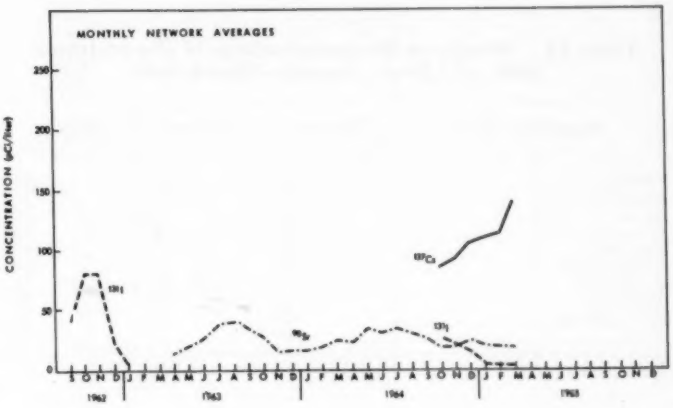

Figure 9. Radionuclide concentrations in Pennsylvania milk

Iodine–131, cesium–137 and potassium–40 concentrations are determined by gamma-scintillation spectroscopy. The resultant gamma spectra are processed using a matrix system of analysis. All iodine–131 levels were below

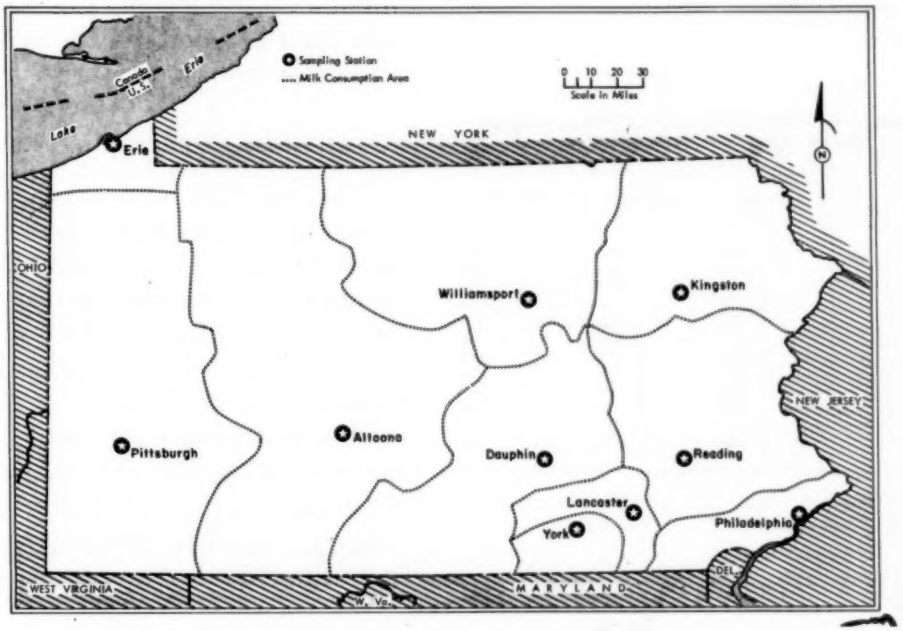

Figure 8. Pennsylvania milk sampling stations and milk consumption areas

the minimum detectable concentration of 10 pCi/liter during January–March 1965. Cesium–137 and potassium–40 results are given in tables 15 and 16, respectively.

Table 14. Strontium-90 concentrations in Pennsylvania milk (pCi/liter), January–March 1965

Sampling location	January	February	March
Altoona	26	24	24
Dauphin	23	18	15
Erie	20	18	22
Kingston	20	16	18
Lancaster	23	22	17
Philadelphia	20	19	20
Pittsburgh	21	22	25
Reading	26	26	25
Williamsport	24	20	18
York	19	17	17
State average	23	20	20

Table 15. Cesium-137 concentrations in Pennsylvania milk (pCi/liter), January–March 1965

Sampling location	January	February	March
Altoona	112	107	111
Dauphin	106	101	96
Erie	143	153	172
Kingston	129	124	245
Lancaster	102	94	85
Philadelphia	95	96	173
Pittsburgh	127	126	126
Reading	124	112	121
Williamsport	92	132	137
York	95	111	121
State average	112	116	139

Table 16. Potassium-40 concentrations in Pennsylvania milk (pCi/liter), January–March 1965

Sampling location	January	February	March
Altoona	1,044	1,124	875
Dauphin	1,140	1,054	900
Erie	1,113	1,116	1,308
Kingston	1,156	1,046	1,600
Lancaster	1,088	1,150	1,000
Philadelphia	1,051	1,038	1,781
Pittsburgh	1,094	1,076	900
Reading	1,127	1,077	928
Williamsport	890	1,102	1,102
York	979	1,129	1,129
State average	1,068	1,091	1,152

Previous coverage in *Radiological Health Data:*

Period	Issue
September 1962–November 1963	*March 1964*
December 1963–March 1964	*July 1964*
April–June 1964	*October 1964*
August–September 1964	*February 1965*
October–December 1964	*June 1965*

5. Radiostrontium in milk[3] January–March 1965

Health and Safety Laboratory
U.S. Atomic Energy Commission

In 1954 the Health and Safety Laboratory began monitoring strontium–90 in liquid whole milk in New York City to estimate the dietary contribution from ingestion of radiostrontium in milk. Subsequently, powdered milk monitoring was initiated at Perry, New York (1954), and at Mandan, North Dakota (1955). Liquid whole milk monitoring was started in Honolulu, Hawaii, in August 1959.

The New York City sample is a monthly composite of pasteurized milk purchased daily in quart containers at retail stores. Five large dairies are represented in the sample. The Honolulu samples are monthly composites of quart samples of pasteurized milk collected weekly. Samples from two diaries are analyzed and the results are averaged. The Mandan and Perry samples are monthly composites of powdered milk collected in 5-pound lots from plants in each city. The Mandan sample is powdered buttermilk used in cattle feeds. Because of its protein and fat content, this buttermilk powder is used primarily as a milk replacer or feed supplement for calves. The Perry sample is powdered whole milk used for human consumption. The source of the Honolulu milk is a herd on the island of Oahu where the cows are on pasture throughout the year.

Results and discussion

The calcium and strontium–90 concentrations in liquid whole milk are presented in table 17, and the strontium–90 data are plotted in figure 10. The general decreasing trend noted throughout 1964 reflects the traditional spring peak which is also apparent for January through March 1965.

The powdered milk (table 18) and powdered buttermilk (table 19) samples also displayed a spring peak in strontium–90 concentrations (figure 11). The general decreasing trend in strontium–90 levels can be expected.

[3] Data summarized from "Fallout Program Quarterly Summary Report, HASL–161," available from Clearinghouse for Federal Scientific and Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Virginia 22151. Price $4.00.

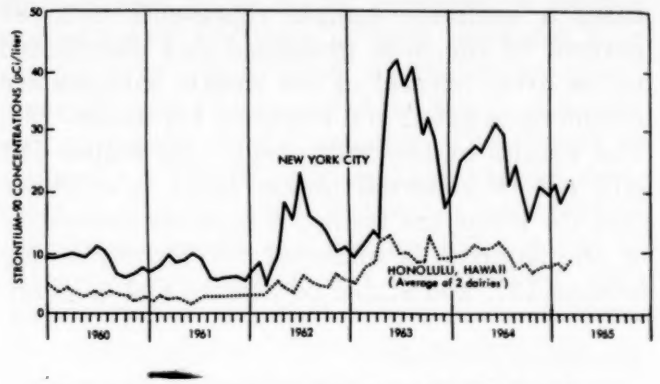

Figure 10. Strontium–90 in liquid milk samples

It is noted that strontium–90 concentrations in powdered milk and liquid whole milk are comparable when it is assumed that 0.1 kg of powdered milk is used to prepare 1 liter of liquid milk.

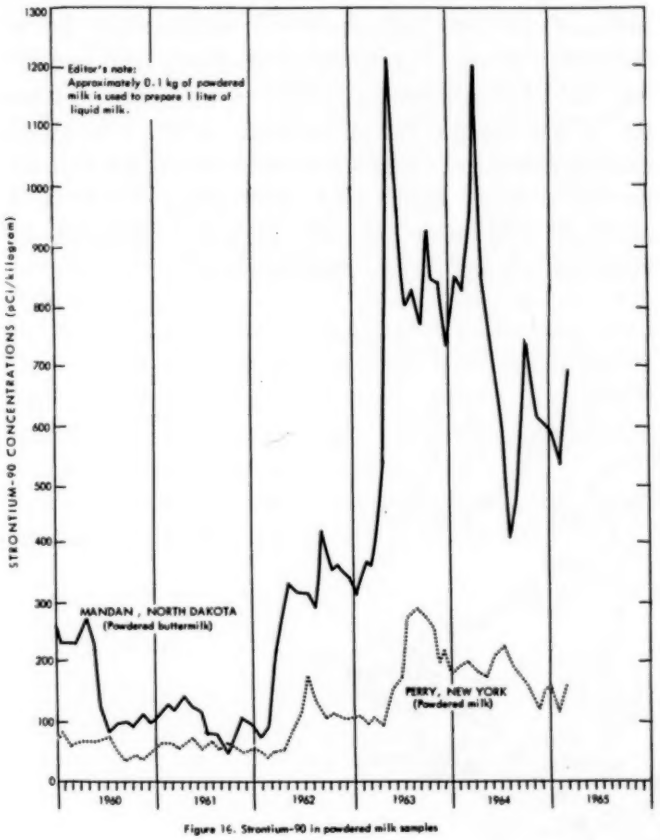

Figure 16. Strontium-90 in powdered milk samples

Figure 11. Strontium–90 in powdered milk samples

Table 17. Strontium-90 and calcium in liquid milk, January–March 1965

Sampling stations and periods	Calcium concentration (g/liter)	Strontium-90 concentration (pCi/liter)	Strontium-90/ calcium ratio (pCi/g Ca)
New York City (averages):			
1959			11
1960			8.0
1961			6.7
1962			12
1963			26
1964			23
January 1965	1.03	21.4	20.8
February 1965	1.02	18.4	18.0
March 1965	1.01	21.4	21.1
Honolulu, Hawaii (averages):			
1959			5.0
1960			3.2
1961			2.4
1962			4.3
1963			8.0
1964			8.6
January 1965	1.04	8.2	7.9
February 1965	1.02	7.8	7.6
March 1965	1.00	8.8	8.9

Table 18. Strontium-90 and calcium in powdered milk, January–March 1965

Sampling station and periods	Calcium concentration (g/kg)	Strontium-90 concentration (pCi/kg)	Strontium-90/ calcium ratio (pCi/g Ca)
Perry, N.Y. (averages):			
1959			8.0
1960			6.5
1961			6.2
1962			11.1
1963			21.6
1964			20.4
January 1965	9.33	166	17.7
February 1965	8.51	121	14.2
March 1965	8.73	166	19.0

Table 19. Strontium-90 and calcium in powdered buttermilk, January–March 1965

Sampling station and periods	Calcium concentration (g/kg)	Strontium-90 concentration (pCi/kg)	Strontium-90/ calcium ratio (pCi/g Ca)
Mandan, N. Dak. (averages):			
1959			26
1960			15
1961			9.4
1962			25
1963			58
1964			62.7
January 1965	10.8	594	54.6
February 1965	10.4	522	50.0
March 1965	10.8	699	61.8

Recent coverage in *Radiological Health Data:*

Period	Issue
April–June 1963	*January 1964*
July–September 1963	*April 1964*
October–December 1963	*July 1964*
January–December 1964	*June 1965*

6. Canadian Milk Network[4] May 1965

Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada

The Radiation Protection Division of the Department of National Health and Welfare began monitoring milk for strontium–90 in November 1955. At first, analyses were carried out on samples of powdered milk obtained from processing plants. However, since January 1963 liquid whole milk has been analyzed instead. With this change, more representative samples of milk consumed can be obtained, and milk sampling locations (figure 12) can be chosen in the same areas as the air and precipitation stations. At present, the analyses include determinations of iodine–131, strontium–89, cesium–137, and strontium–90 as well as stable potassium and calcium.

The milk samples are obtained through the cooperation of the Marketing Division of the Canadian Department of Agriculture. At each station samples are collected three times a week from selected dairies, combined into weekly composites, and forwarded to the radiochemical laboratory in Ottawa. The contribution of each dairy to the composite sample is directly proportional to its volume of sales. In most cases a complete sample represents over 80 percent of the milk processed and distributed in the area. Several of the weekly samples are randomly selected and analyzed for iodine–131. The results of the spot checks for iodine–131 will not be reported unless there is evidence that the levels are rising. A monthly composite of the samples is analyzed for strontium–90, cesium–137, and stable potassium and calcium.

Analytical methods

Radiochemical methods are used for the analysis of iodine–131 (*8*). For the analysis of radiostrontium, carrier strontium is added to a one-liter sample of milk, and the milk is then placed in a tray lined with a polyethylene sheet and evaporated under infrared lamps. The residue is ashed in a muffle-furnace at 450 degrees C., and dissolved in dilute nitric acid; strontium is separated by fuming nitric acid precipitation. The combined strontium–89 and strontium–90 are determined by counting in a low-background beta counter. Strontium–90 is determined separately by extracting and counting its yttrium–90 daughter, while strontium–89 is estimated by difference from the total radiostrontium measurement. Appropriate corrections are made for self-absorption and counter efficiency at all stages. Calcium is determined by flame photometry.

[4] This report was prepared from information and data in the June 1965 monthly report, "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

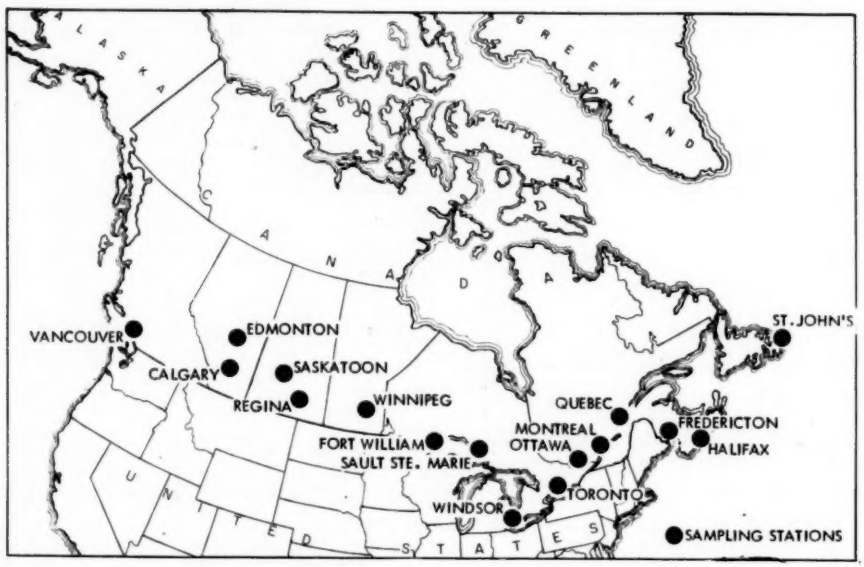

Figure 12. Canadian milk sampling stations

Cesium–137 is determined by gamma spectroscopy using a scintillation crystal and a multichannel pulse height analyzer. A sample consisting of 4.5 liters of milk is placed in a sample tray constructed in the form of an inverted well to accommodate the 5- x 4-inch sodium iodide crystal detector. The sample is counted for 100 minutes and the gamma spectrum is then recorded. Estimates are made of the potassium–40 and cesium–137 content of the milk by comparison of the spectrum with the spectra of standard preparations of these two radionuclides. With this method the potassium–40 concentration is determined and the Compton contribution of this radionuclide to the cesium–137 photopeak is subtracted to obtain the cesium–137 concentration. The stable potassium content is estimated from the potassium–40 concentration.

Sources of error

In the iodine and strontium determinations, tests indicate that the statistical error (95 percent confidence level) in the chemical operations involved is about plus-or-minus 10 percent. This value is independent of the concentration of the radioisotope in the milk because it depends only on the recovery of the carrier. In the gamma spectrometric determination of cesium–137, no recovery factor is involved.

The chemical procedures error must be combined with the counting error which depends primarily on the concentration of the nuclide in the sample, the background radiation, and the length of time the sample and background are counted. This counting error has been evaluated mathematically for the particular counting arrangement used.

The overall errors, estimated on the basis indicated above, are given in table 20.

Table 20. Total error for various radionuclide concentrations in milk [a]

Radionuclide	Error for 10 pCi/liter	Error for 50 pCi/liter	Error for 100 pCi/liter
Strontium-89	25%	20%	15%
Strontium-90	15%	10%	10%
Iodine-131	50%	20%	10%
Cesium-137	60%	20%	10%

[a] All errors are 2σ values, representing 95 percent confidence levels.

Results

Table 21 presents monthly averages of strontium–90, cesium–137, stable calcium and potassium in Canadian whole milk. Spot checks for iodine–131 and strontium–89 indicate that all samples had insignificant levels of these radionuclides.

The results show that radionuclide concentrations in Canadian whole milk remained well below the levels permissible on health grounds.

Table 21. Stable elemements and radionuclides in Canadian whole milk, May 1965

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.14	1.5	29.8	98
Edmonton	1.04	1.5	25.7	91
Ft. William	1.02	1.7	40.9	182
Fredericton	1.15	1.6	33.9	176
Halifax	1.15	1.6	38.1	218
Montreal	1.13	1.6	28.6	144
Ottawa	1.16	1.6	18.0	89
Quebec	1.12	1.6	36.1	229
Regina	1.17	1.6	34.5	102
St. John's, Nfld	1.14	1.6	35.5	178
Saskatoon	1.15	1.6	37.6	89
Sault Ste. Marie	1.13	1.6	37.4	153
Toronto	1.10	1.6	13.3	76
Vancouver	1.14	1.6	35.2	164
Windsor	1.15	1.6	11.0	78
Winnipeg	1.08	1.6	31.8	123
Average	1.12	1.6	30.5	137

7. Pan American Milk Sampling Program May 1965

Pan American Health Organization, and Public Health Service

In accordance with a joint agreement, the PAHO (Pan American Health Organization) and the PHS (Public Health Service) developed a collaborative program for furnishing assistance to health authorities in the Americas engaged in developing programs in radiological health.

Under this agreement, the PHS Division of Radiological Health furnishes to PAHO, on a loan basis, limited quantities of essential items of equipment and the requisite laboratory services to establish a surveillance program.

Sampling procedure

Initially, sampling stations were established in Chile, Jamaica, Peru, and Venezuela. In August 1963, the program was expanded to include a milk sampling station in Caracas, Venezuela. Between April 1964 and August 1964, additional stations were established in Jamaica at Kingston, Montego Bay, and Mandeville. Sampling varies according to local procedures.

Under the direction of the Venezuelan Institute for Scientific Investigation, weekly samples are collected, preserved with formaldehyde and composited monthly.

Jamaica, under the direction of the Ministry of Health, collects one monthly composite on a rotating basis from one of the three principal milk areas: Montego Bay (Montpelier), Mandeville, and Kingston (Spanish Town). To reduce spoilage it was necessary to establish cooling stations in the western parishes where the milk is received prior to shipping to the Condensery in Kingston. All samples are sent to the PHS Southeastern Radiological Health Laboratory for analyses.

Analytical procedures

Iodine–131 and cesium–137 are determined by gamma-scintillation spectrometry. Strontium–89, strontium–90, and barium–140 are determined radiochemically (*9*). Analytical errors are discussed in the "Analytical Procedures, Pasteurized Milk Network."

Data presentation

Table 2 presents stable calcium and potassium, strontium–89, strontium–90, and cesium–137 monthly average concentrations. The monthly average of iodine–131 and barium–140 concentrations in milk was less than 10 pCi/liter except for Caracas, Venezuela, where a concentration of 20 pCi/liter for iodine–131 was observed.

For comparison purposes, the radionuclide concentrations at Cristobal, Canal Zone, and San Juan, Puerto Rico, are presented.

Table 22. Stable element and radionuclide concentrations in milk, PAHO, May 1965

Sampling station	Calcium (g/liter)	Potassium (g/liter)	Strontium-89 (pCi/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Canal Zone: Cristobal	1.08	—	<5	4	35
Jamaica: Kingston	NS	NS	NS	NS	NS
Mandeville	NS	NS	NS	NS	NS
Montego Bay	1.19	1.46	<5	19	365
Puerto Rico: San Juan	1.09	—	<5	12	45
Venezuela: Caracas[a]	1.10	1.60	<5	5	30

[a] May 1965 iodine-131 concentrations in milk were 20 pCi/liter.
Symbol: NS-no sample collected

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APPLICATION OF RADIONUCLIDE CONCENTRATIONS IN MILK TO INTAKE GUIDES, MAY 1964–MAY 1965

Division of Radiological Health
Public Health Service

The concentrations of specific radionuclides in milk analyzed as part of the Pasteurized Milk Network (PMN) are reported on a monthly basis in *RHD*. In terms of radiological health surveillance activities, an important aspect of these data is the estimation of resultant radiation dose to population groups.

Approximate relationships between certain radionuclide intakes and dose have been applied to the formulation of daily intake guides (*1*) and permissible concentrations in selected environmental media (*2*). Although these guides are not themselves directly applicable to worldwide fallout, a comparison with environmental contamination levels does yield a measure of population dosage. In general, intake–dose and dose–biological effect relationships used in formulating the guides cited are based on continuous intake over an entire lifetime. However, for general surveillance purposes, yearly average intakes, used with discretion, may be compared directly with the levels adopted as lifetime intake guides. Thus, the radionuclide concentrations in milk, averaged over a year's time, together with milk consumption data, might be used in conjunc-proximate the radiation dose to a specific population group from a specific radionuclide. Table 1 presents annual averages of radionuclide concentrations in milk sampled by the PMN. Limited data are available for estimating the average daily milk consumption (on a volume basis) for specific age groups in the U.S. population (*3*, *4*).

Total dietary intake is of prime interest, and since the intake via milk consumption constitutes only a portion of the total radionuclide intake, the relationship of milk intake to total dietary intake is of importance in evaluating milk surveillance data. The Federal Radiation Council (*5*) notes: "A number of studies have shown that conservative estimates of the strontium–90 to calcium ratio in the total diet may be made by multiplying the ratio of strontium–90 to calcium in milk in a particular locality by 1.5." [1] Thus, a rough index of the total dietary intake of strontium–90 on an annual basis may be made from PMN annual averages by using this factor and the assumptions of approximately 1.2 grams of calcium per liter in PMN samples and a 1.0 gram daily intake of calcium.

In the case of iodine–131, milk can be considered the major source because of the rapid distribution and consumption of fresh milk. With most other foods, normal processing and distribution allows time for this short-lived nuclide to decay to insignificant levels.

The situation with respect to strontium–89 is more complicated. Its half-life of some 50 days makes it difficult to estimate the relative contribution made by sources other than milk to the total dietary intake.

The relative contribution of milk to the total dietary intake of cesium–137 is not well defined and depends principally on the amount of freshly deposited cesium–137 on products used for human and animal consumption, and the progress of cesium–137 through the food chain.

The data in table 1 are calculated as follows: results from all samples collected in each week (Sunday through Saturday) are averaged, and the averages for all weeks terminating in each of 12 consecutive months are averaged to obtain the annual average.[2] To obtain the annual average daily intake (pCi/day) of radionuclides from milk, the annual average concentration values (pCi/liter) in table 1 must be multiplied by the annual average daily consumption (liters/day) of milk.

[1] This ratio may vary from 1 to 2, depending on changes in rate of fallout deposition and relative consumption of nonmilk products whose contamination reflects temporal and local deposition patterns (*6*).

[2] Beginning with the October 1963 data, iodine–131 values of <10 pCi/liter are considered to be zero for averaging purposes; previously, 5 pCi/liter was used for calculating the averages.

Table 1. Average radionuclide concentrations in milk for the twelve month periods,[a] May 1964–April 1965 and June 1964–May 1965, pCi/liter

Sampling locations		Strontium-89		Strontium-90		Iodine-131		Cesium-137	
		May 1964–Apr 1965	June 1964–May 1965	May 1964–Apr 1965	June 1964–May 1965	May 1964–Apr 1965	June 1964–May 1965	May 1964–Apr 1965	June 1964–May 1965
Ala:	Montgomery	3	3	21	20	0	0	66	58
Alaska:	Palmer	3	3	20	19	0	1	93	85
Ariz:	Phoenix	3	3	5	5	0	0	25	24
Ark:	Little Rock	3	3	40	37	1	1	86	74
Calif:	Sacramento	3	3	7	7	0	1	31	33
	San Francisco	3	3	8	8	0	0	36	35
C. Z:	Cristobal	3	3	5	5	0	0	47	45
Colo:	Denver	3	3	19	19	0	0	81	80
Conn:	Hartford	3	3	18	18	0	0	106	98
Del:	Wilmington	3	3	21	19	1	1	89	81
D. C:	Washington	3	3	19	18	0	1	64	59
Fla:	Tampa	3	3	15	14	0	0	217	208
Ga:	Atlanta	3	3	28	27	0	0	106	96
Hawaii:	Honolulu	3	3	12	11	0	0	72	70
Idaho:	Idaho Falls	3	3	23	22	0	0	117	108
Ill:	Chicago	3	3	18	18	0	0	91	86
Ind:	Indianapolis	3	3	19	18	1	1	75	70
Iowa:	Des Moines	3	3	24	23	0	3	68	64
Kans:	Wichita	3	3	20	19	0	0	54	50
Ky:	Louisville	3	3	26	25	0	0	59	54
La:	New Orleans	4	4	46	44	0	0	105	94
Maine:	Portland	3	3	26	25	1	1	161	152
Md:	Baltimore	3	3	21	20	0	0	72	65
Mass:	Boston	3	3	28	26	0	0	164	154
Mich:	Detroit	3	3	17	17	2	2	90	85
	Grand Rapids	3	3	20	19	1	1	99	94
Minn:	Minneapolis	4	4	28	27	0	1	105	99
Miss:	Jackson	3	3	37	35	0	0	76	67
Mo:	Kansas City	4	3	25	23	0	4	58	54
	St. Louis	3	3	20	19	0	1	58	54
Mont:	Helena	3	3	21	19	1	3	114	103
Nebr:	Omaha	3	3	23	22	0	1	68	63
Nev:	Las Vegas	3	3	8	8	1	1	54	50
N. H:	Manchester	3	3	27	26	1	1	183	172
N. J:	Trenton	3	3	18	17	1	1	89	82
N. Mex:	Albuquerque	2	2	11	10	1	1	47	45
N. Y:	Buffalo	3	3	18	18	0	0	112	107
	New York	3	3	23	22	1	1	117	110
	Syracuse[b]	3	3	17	16	0	0	103	94
N. C:	Charlotte	3	3	35	34	0	0	88	79
N. Dak:	Minot	7	5	53	51	0	0	134	129
Ohio:	Cincinnati	3	3	19	18	0	0	69	64
	Cleveland	3	3	20	19	0	1	94	89
Okla:	Oklahoma City	3	3	21	20	0	0	54	51
Ore:	Portland	4	4	27	25	0	0	128	121
Pa:	Philadelphia	3	3	19	18	0	0	87	79
	Pittsburgh	3	3	27	27	0	0	117	110
P. R:	San Juan	3	3	12	12	0	0	62	58
R. I:	Providence	3	3	21	20	0	0	123	116
S. C:	Charleston	3	3	31	30	0	0	107	100
S. Dak:	Rapid City	4	4	36	34	0	0	130	126
Tenn:	Chattanooga	3	3	36	34	0	0	85	76
	Memphis	3	3	29	28	0	0	54	48
Tex:	Austin	3	3	8	8	0	0	33	31
	Dallas	3	3	18	18	0	0	47	44
Utah:	Salt Lake City	5	3	23	24	0	0	136	131
Vt:	Burlington	3	3	24	23	2	2	133	125
Va:	Norfolk	3	3	18	17	0	1	74	68
Wash:	Seattle	5	4	27	25	0	0	133	127
	Spokane	4	3	26	26	0	0	116	110
W. Va:	Charleston	3	3	22	20	0	1	55	49
Wis:	Milwaukee	3	3	16	15	1	2	101	96
Wyo:	Laramie	4	4	18	17	0	0	86	82
Network average		3	3	22.0	21.1	0	1	91	85

[a] Annual averages were computed on basis of 52 weekly averages. Annual averages for barium-140 at each station were <2 pCi/liter.
[b] Annual averages were computed on basis of 48 weekly averages.

Monthly variations of radionuclide concentrations in milk are influenced by a number of combined causes such as meteorologic conditions and dairying practices, apart from considerations of original sources of radionuclides. The moving yearly average (table 1) obtained by updating the previous 12 month average by one month, shows variations averaged over the year and tends to minimize purely seasonal variations.

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ESTIMATED DAILY INTAKE OF RADIONUCLIDES IN CALIFORNIA DIETS, JULY–OCTOBER 1964

Bureau of Radiological Health
California State Department of Public Health

Since January 1964, the Bureau of Radiological Health, California State Department of Public Health, has made estimates of radionuclide levels in the diets of Californians (*1*).

Recognizing that a "standard" or "typical" diet does not exist due to variations in individual tastes, an effort was made to select a diet which was reasonably representative of the food consumed in a given area. This objective was met by utilizing the "house" diet of a hospital in each of the 20 geographic areas of interest.

Hospitals were chosen as the source of diet samples under the hypothesis of their being as "reasonably representative" as any other source. General hospitals exist in each of the selected geographic areas and operate with trained dietitians. There is good reason to believe that hospitals utilize foods which are marketed in their respective communities. Also, working relations for entry into hospitals existed through the State Bureau of Nutrition and Bureau of Hospitals.

Sampling procedure

In general, the sampling procedure is the same at each hospital. Samples are collected once every 2 months at each facility. Each sample represents the edible portion of the regular meals (the standard diet) for a full 7-day week (21 consecutive meals).

After each sample is collected, it is suitably preserved and shipped to the Sanitation and Radiation Laboratory. Accompanying each sample is a record prepared by the dietitians indicating the types and quantities of food included.

Analytical procedures

After weighing at the Laboratory, each sample is homogenized, dried, and ashed prior to stable calcium, potassium, strontium, and sodium determinations.

The radiochemical analyses are based upon three basic procedures: chemical separation of strontium, analysis of radium–226, and gamma spectral analysis of a gallon of the wet sample.

Data and discussion

The resultant estimates of daily intake of radionuclides in the California diets are given in tables 1 and 2 for July through October 1964.

It should be noted that levels of radioactivity were observed to be far below those levels for which consideration should be given to protective health action.

Table 1. Estimated daily intake of radionuclides in California diets,[a] July–August 1964

City	Kg per capita per day[b]	pCi/capita/day							Grams/capita/day			
		^{89}Sr	^{90}Sr	^{226}Ra	^{137}Cs	^{95}Zr	^{54}Mn	^{141}Ce ^{144}Ce	K[c]	Na	Ca	Stable Sr
Bakersfield	2.1	0	22	0.8	34	29	0	8	2.9	3.5	1.0	.003
Berkeley	2.4	0	18	0	49	32	7	61	2.6	4.0	0.8	.003
Bishop	1.6	4	14	0.4	50	27	0	0	2.4	2.6	0.8	.002
Brawley	2.3	0	28	2.4	39	33	0	21	3.5	4.4	1.1	.002
Crescent City	2.3	0	28	0.4	125	55	4	13	2.5	3.9	0.9	.003
Eureka	2.0	0	8	0.4	50	30	2	42	2.6	3.0	1.0	.003
Fresno	2.4	0	49	0	70	19	0	75	2.9	4.2	1.0	.004
Los Angeles	2.7	0	10	0.1	47	61	3	25	2.9	3.4	0.9	.003
Needles	1.1	0	12	0.2	33	18	1	20	1.6	2.9	0.4	.002
Quincy	1.8	0	62	1.1	41	28	0	36	2.3	2.5	0.6	.002
Redding	2.1	0	29	0.5	47	27	0	2	2.7	4.1	1.0	.004
Sacramento	2.7	0	25	0.5	44	27	0	34	3.1	5.3	1.4	.004
Salinas	2.1	0	14	0.2	50	26	0	27	2.7	3.4	0.8	.003
San Bernardino	1.9	0	29	0.2	16	25	0	0	2.7	3.3	0.9	.003
San Diego	2.0	0	5	0.2	42	28	0	31	2.7	3.2	0.8	.003
San Luis Obispo	1.3	0	18	0.4	32	18	2	25	1.9	2.8	0.6	.003
Santa Barbara	2.1	0	27	0.3	55	33	0	46	3.1	3.4	1.2	.003
Santa Rosa	2.5	0	17	0.4	43	34	0	19	3.3	4.5	1.2	.004
Susanville	2.2	0	12	0.1	72	38	0	47	3.0	4.8	0.9	.004
Ukiah	2.1	0	26	0.2	64	26	0	44	2.3	2.5	1.0	.003

[a] Based on analyses of hospital standard diets located in listed cities.
[b] Kilograms of food per person per day in this diet.
[c] Natural potassium contains 0.0119 percent of radioactive ^{40}K.

Table 2. Estimated daily intake of radionuclides in California diets,[a] September–October, 1964

City	Kg per capita per day[b]	pCi/capita/day							Grams/capita/day			
		^{89}Sr	^{90}Sr	^{226}Ra	^{137}Cs	^{95}Zr	^{54}Mn	^{141}Ce ^{144}Ce	K[c]	Na	Ca	Stable Sr
Bakersfield	2.4	0	16	1.2	23	30	0	0	3.1	3.5	1.2	.002
Berkeley	2.2	0	28	1.6	53	31	0	26	2.9	3.2	1.2	.002
Bishop	1.6	0	13	0.8	55	0	[d] —	0	1.8	2.1	0.7	.001
Brawley	2.6	0	9	0.8	28	0	—	0	2.1	2.4	0.7	.001
Crescent City	2.1	0	47	4.0	90	44	0	0	3.0	4.0	1.0	.002
Eureka	2.4	0	20	2.0	66	57	0	0	3.1	3.5	1.4	.002
Fresno	2.6	0	28	2.4	50	42	[e] 0.8	0	3.2	4.6	1.3	.002
Los Angeles	2.6	0	27	1.6	110	65	—	0	2.8	3.3	0.7	.002
Needles	1.9	0	33	2.9	47	31	0	0	2.7	2.9	0.8	.002
Quincy	1.9	0	9	1.2	52	28	0	0	2.9	2.9	0.6	.002
Redding	2.2	0	11	2.2	49	31	0	0	3.4	4.8	1.3	.002
Sacramento	2.7	0	17	4.4	81	[e] 13	—	[e] 6	3.4	5.4	1.3	.002
Salinas	2.5	0	12	3.0	47	0	—	36	3.4	3.8	0.9	.002
San Bernardino	2.2	0	11	2.1	82	32	—	0	3.6	3.5	1.2	.002
San Diego	2.2	0	10	1.6	78	42	—	0	3.2	3.4	0.8	.002
San Luis Obispo	1.4	0	12	0.7	45	29	0	0	1.8	2.8	0.6	.001
Santa Barbara	1.8	0	14	2.6	36	30	0	0	3.1	3.4	0.8	.002
Santa Rosa	2.4	0	12	2.8	117	44	—	0	3.0	3.2	1.2	.002
Susanville	1.9	0	33	1.6	—	—	—	—	2.7	3.0	0.8	.002
Ukiah												

[a] Based on analyses of hospital standard diets located in listed cities.
[b] Kilograms of food per person per day in this diet.
[c] Natural potassium contains 0.0119 percent of radioactive ^{40}K.
[d] Dash indicates sample lost in laboratory procedures.
[e] When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best available estimate, but is not statistically significant. Where no value is given, no activity was detected.

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STRONTIUM-90 IN TRI-CITY DIETS NOVEMBER 1964–JANUARY 1965[1]

Health and Safety Laboratory Atomic Energy Commission

Since March 1960, the Health and Safety Laboratory, through its quarterly diet study, has made estimates of the strontium–90 content of the average diet of individuals living in New York City, San Francisco, and Chicago.

Selected foods representing 19 food categories are purchased at each of these 3 cities about every 3 months and are analyzed for strontium–90. Using data from the U.S. Department of Agriculture (*1*), the annual consumption by an average individual in the same 19 food categories can be estimated. The annual dietary intake of strontium–90 can be estimated by summing the contributions from each category.

The consumption data are based on a weight-as-purchased basis. Before the food samples for the Tri-City Diet Study are ashed for radiochemical analysis, they are prepared to a certain degree as if for actual consumption. For example, fruits are peeled, eggs are shelled, and poultry is boned. Therefore, concentrations of radioactivity in foods as reported in the Tri-City Diet Study are based on the trimmed weight. No correction is made for the waste.

After two samplings at each city it was found that the calcium content of most food categories did not vary among cities, nor did it vary significantly with time. Calcium analyses of dietary components were performed for the third time recently, and further confirmed this result (*2*). Calcium analyses were therefore discontinued and average calcium content of foods was computed and used to estimate the average annual intake of this mineral. Details of the sampling system and a discussion of the results obtained have been summarized (*3*).

Results of the November 1964—January 1965 sampling are presented in table 1. The variation with time of the daily intake of strontium–90 in the three cities is plotted in figure 1.

Discussion

The previously noted geographic distribution pattern of strontium–90 in the diet is seen to persist as it has since the initial samplings in 1960. Levels have been highest in New York City and lowest in San Francisco. In New York

[1] Data from Fallout Program Quarterly Summary Report, HASL—161:213–215 (July 1, 1965).

Table 1. Average per person dietary consumption and strontium-90 intake, November 1964–January 1965 sampling

Food category	Average U.S. consumption		Strontium-90 intake					
			New York City November 1964		Chicago January 1965		San Francisco December 1964	
	Diet (kg/yr)	Calcium (g/yr)	pCi/kg [a]	pCi/yr	pCi/kg [a]	pCi/yr	pCi/kg [a]	pCi/yr
Bakery products	37	37.0	24.6±1.0	910	21.0±0.8	777	13.0±1.0	481
Whole grain products	11	10.0	75.4±2.5	829	47.5±1.4	522	26.8±1.0	295
Eggs	16	9.1	4.0±0.1	64	5.2±0.1	83	5.5±0.1	88
Fresh vegetables	43	15.0	23.2±0.7	998	8.7±0.4	374	2.9±0.3	125
Root vegetables	17	6.1	14.6±0.5	248	11.4±0.4	194	8.4±0.3	143
Milk	221	234.3	20.6±1.6	4,508	9.3±0.3	2,060	7.2±0.3	1,591
Poultry	17	9.2	3.5±0.1	59	1.5±0.1	26	1.1±0.1	18
Fresh fish	8	10.8	1.6±0.1	13	1.6±0.1	13	0.4±0.1	3
Flour	43	8.6	30.4±0.5	1,307	17.0±0.2	731	6.4±0.2	275
Macaroni	3	0.7	16.9±0.5	51	17.0±0.8	51	9.9±0.3	30
Rice	3	1.1	0.6±0.2	2	10.1±0.3	30	3.3±0.2	10
Meat	73	10.9	4.0±0.2	292	2.3±0.1	168	1.8±0.1	131
Shellfish	1	0.8	6.9±0.2	7	1.1±1.1	1	1.9±0.2	2
Dried beans	3	2.9	21.7±1.4	65	26.9±1.5	80	19.8±1.6	59
Fresh fruit	68	12.6	11.4±0.3	775	20.3±0.4	1,380	3.8±0.2	258
Potatoes	45	5.8	9.5±0.1	428	8.6±0.5	387	4.4±0.3	198
Canned fruit	26	1.3	2.6±0.8	68	3.9±0.1	101	1.9±0.1	49
Fruit juices	19	1.7	3.8±0.2	72	5.5±0.3	104	2.8±0.2	53
Canned vegetables	20	4.2	7.9±0.6	158	1.3±0.5	26	5.0±0.3	100
Annual intake	674	383		10,854		7,108		3,909
pCi ^{90}Sr/g Ca in total diet			28.3		18.6		10.2	

[a] Error terms are one standard deviation (due to counting).

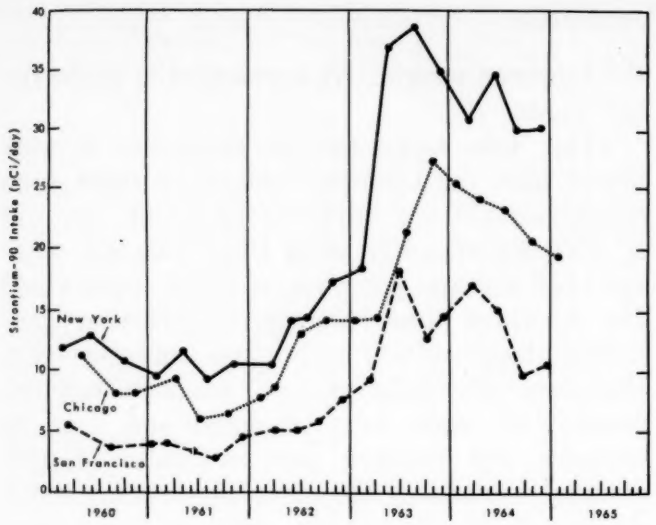

Figure 1. Strontium–90 daily intake in Tri-City diet study

City and Chicago the strontium–90 intake is observed to decrease with respect to the previous sampling period three months earlier. The San Francisco strontium–90 intake is observed to increase slightly. Due in part to its high annual consumption, milk continues to be the predominant source of strontium–90 in the diet.

A discussion of cesium–137 intakes as reflected in the Tri-City Diet Study is presented elsewhere (*4*).

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Recent coverage in *Radiological Health Data:*

Period	Issue
Sixteenth Sampling (February 1964—April 1964)	*December 1964*
Seventeenth Sampling (July–September 1964)	*March 1965*
Eigtheenth Sampling (August–October 1964)	*June 1965*

DIETARY INTAKES AND BODY BURDENS OF CESIUM-137[1]

Joseph Rivera[2]

Cesium–137 concentrations in foods purchased in New York City, Chicago, and San Francisco during the last quarter of 1964 were determined radiochemically (*1*). The results of these analyses are shown in table 1.

Since the foods were ashed at 482° C for 24 hours prior to analysis, it is known that some cesium–137 losses must have occurred due to volatilization. Preliminary experiments comparing the activities in wet and dry ashed aliquots of milk, flour, and meat indicate that these losses are about 20 percent. In view of these findings, the daily intakes of cesium–137 calculated from the concentrations of cesium–137 found were increased by 20 percent. These estimates of daily intakes, along with similar estimates based on the analyses of foods purchased at the three cities during the last quarters of 1962 and 1963, are shown graphically in figure 1.

Although estimates of cesium–137 intake were made at each city only at the end of each year, an indication of how well the results represent the intake for the entire year may be deduced by comparing the observed cesium–137 body burdens of people with body burdens calculated using the estimated daily intakes.

[1] Taken from the Atomic Energy Commission's *Fallout Program Quarterly Summary Report, HASL–158*:306–309. Clearinghouse for Federal Scientific and Technical Information, 5285 Port Royal Road, Springfield, Virginia 22151 (April 1, 1965). Price $4.00.

[2] Mr. Rivera is a physicist on the staff of the Environmental Studies Division of the Health and Safety Laboratory, U.S. Atomic Energy Commission, 376 Hudson Street, New York, New York 10014.

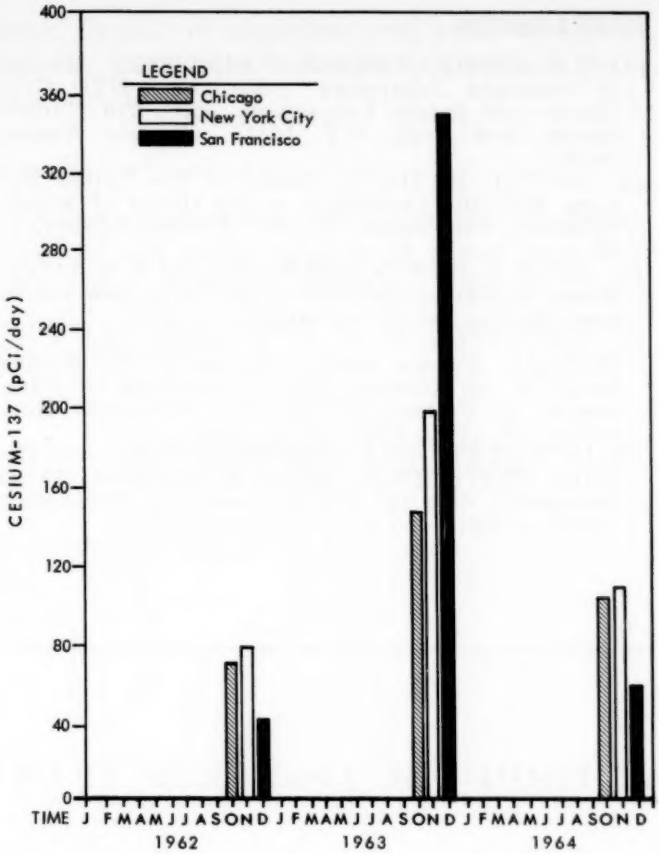

Figure 2. Estimated daily intake of cesium–137 in Tri-City diets

It has been found that in adult man close to 100 percent of ingested cesium–137 is absorbed, and that the long-term retention of the cesium–137 is described reasonably well by a single exponential, with a biological half-life of 100 days (*2*).

The body burden of cesium–137 resulting from ingestion of cesium–137 can therefore be given by:

$$Q(t) = Q_0\,(t)\,e^{-0.693t/100} + \frac{P(100)}{0.693}\,(1 - e^{-0.693t/100})$$

where "Q" is the body burden in pCi resulting from the ingestion of "P" pCi/day of cesium–137 for "t" days, and "Q_o" is the body burden at time zero.

From the date of Cohn, *et al.* (*3*) and Gustafson, *et al.* (*4*), it is estimated that at the beginning of 1962 the body burdens of New York and Chicago residents were about 30 pCi/g K. Assuming a potassium content of standard man of 140 g (*5*), calculations from the diet values of the cesium–137 body burdens of New York and Chicago residents were possible. The results, along with observed levels of cesium–137 for New York and Chicago residents determined by whole body counting, are shown in table 2. Similar data on the body burdens of cesium–137 for San Francisco residents were not available; therefore, calculations for this site could not be made.

The agreement between observed and calculated results is surprisingly good and suggests that the diet estimates are reasonable. It is expected that more quantitative estimates of the cesium–137 losses incurred during the ashing of foods will soon be available. With this information and perhaps a more frequent sampling of foods during 1965, accurate predictions of the average adult body burdens of cesium–137 that will exist in 1966 should be possible.

Table 1. Cesium-137 in Tri-City diets, 1964 sampling

Food category	kg/yr	New York City, November 1964		Chicago, October 1964		San Francisco, December 1964	
		pCi/kg	pCi/yr	pCi/kg	pCi/yr	pCi/kg	pCi/yr
Bakery products	37	48.3	1,787	52	1,924	14.0	518
Whole grain products	11	120.0	1,320	104	1,144	11.0	121
Eggs	16	11.4	182	17	272	12.8	205
Fresh vegetables	43	3.0	129	7.2	310	65.8	2,829
Root vegetables	17	5.0	85	1.1	19	9.1	155
Milk	221	55	12,155	42	9,282	23	5,083
Poultry	17	21.0	357	42	714	5.0	85
Fresh fish	8	15.1	121	203	1,624	6.7	54
Flour	43	60.3	2,593	81	3,483	7.2	310
Macaroni	3	126.6	362	162	486	72.0	216
Rice	3	32.6	98	67	201	46.4	139
Meat	73	117.9	8,607	101	7,373	20.1	1,467
Shellfish	1	12.7	13	8.1	8	6.3	6
Dried beans	3	218.7	656	47	141	6.8	20
Fresh fruit	68	16.1	1,095	13	884	44.6	3,033
Potatoes	45	17.0	765	8.7	392	38.5	1,733
Canned fruit	26	10.7	273	28	728	24.5	637
Fruit juices	19	32.4	616	28	532	4.1	78
Canned vegetables	20	4.9	98	19	380	6.1	122
pCi/yr			31,311		29,897		16,811
pCi/day *			101.3		102.4		57.6

* Corrected for loss in ashing.

Table 2. Cesium-137 intakes and body burdens

Year and location	Average daily intake, P, during year (pCi/day)	Body burdens at end of year (pCi/g K)	
		Calculated	Observed
1962			
New York	78	74	55
Chicago	71	67	54
1963			
New York	196	185	140
Chicago	145	138	112
1964			
New York	106	102	110
Chicago	102	97	~90

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STRONTIUM-90 IN CANADIAN WHEAT FROM THE 1963 CROP YEAR [1]

E. R. Samuels [2]

The measurement of strontium–90 in Canadian wheat was started in 1959 by the Radiation Protection Division as a part of its nationwide fallout study program. Prior to this, the analyses were carried out by Atomic Energy of Canada, Limited. Since wheat and wheat flour are important cereal products in Canada, this project was undertaken to obtain some measure of the possible contribution of these products to the population's intake of strontium–90 and at the same time provide some information as to the mode of entry of fallout radionuclides into the wheat grain.

This report presents the results of measurements made on Canadian hard red spring wheat grown and harvested during 1963. Data for previous crop years have already been published (*1–3*).

Sampling and analytical procedures

Composite samples of wheat are obtained annually from nine sampling districts representing the major wheat growing areas of Canada (figure 1). Sampling is carried out in such a manner that the final composite samples are fully representative of the particular crop year. The samples for a given year are received at the Radiation Protection Laboratory by the spring of the following

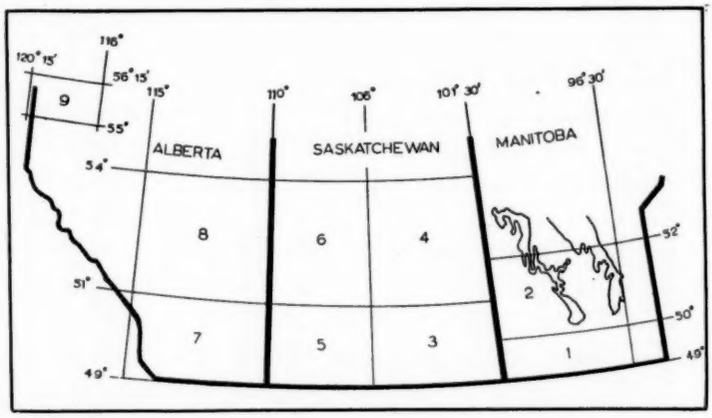

Figure 1. Wheat sampling districts of Canada

[1] Taken from *Data From Radiation Protection Programs*, 3:3–8 (April 1965).

[2] Dr. Samuels is Chemist-in-Charge, Analytical Laboratories, Radiation Protection Division, Department of National Health and Welfare, Brookfield Road, Ottawa 8, Canada.

year. Details of sampling and analytical procedures have been reported in previous publications (*1–3*).

Results and discussion

The results of the determination of strontium–90 and stable calcium in wheat from the 1963 crop year are given in table 1. These values are the result of at least duplicate determinations.

Table 1. Strontium-90 in Canadian hard red spring wheat, crop year 1963

District	Production in millions of bushels	Calcium g/kg wheat	Strontium-90	
			pCi/kg wheat	pCi/g Ca
1	31.1	0.32	143	447
2	19.0	0.31	178	574
3	125.5	0.31	196	632
4	109.9	0.33	211	639
5	64.2	0.36	184	511
6	122.6	0.34	259	762
7	33.4	0.44	210	477
8	95.3	0.36	315	875
9	3.9	0.37	217	581
Averages (weighted for production)		0.35	227	665

The overall average strontium–90 values (weighted for production) for 1963, together with values obtained for previous years, are presented graphically in figures 2 and 3. Data are expressed as picocuries per kilogram wheat (pCi/kg wheat) and picocuries per gram calcium (pCi/g Ca), respectively.

The results in table 1 show significant variations in the strontium–90 levels of wheat grown in the different geographical areas. The lowest levels were found in Manitoba (Districts 1 and 2) and the highest levels in Central Alberta (District 8). The levels of strontium–90 were on the whole highest in the northern areas (51°–54° N) with the southern areas (49°–51° N) showing appreciably lower values. The observations are consistent with data reported for previous years (*1–3*).

The average concentration of strontium–90 in Canadian wheat grown during 1963 increased by a factor of about 3 over that observed in 1962. Similar results have been reported for 1963 U.S. wheat (*4,5*). It should be noted, however, that the concentrations reported are for the whole wheat grain and not for wheat flour. Studies on wheat and milling products (*3–5*) have clearly demonstrated that most of the strontium–90 is concentrated in the bran fraction with a relatively small amount being found in patent flour. Grummitt (*3*) found that flour contained 10 percent of the strontium–90 content of whole wheat while 76 percent was found in the bran fraction. The recent work of Pfeifer, *et al.* (*6*) on milling products from a 1963 Illinois wheat produced results in agreement with Grummitt's findings. The use of patent flour should therefore contribute very little to the population's intake of strontium–90.

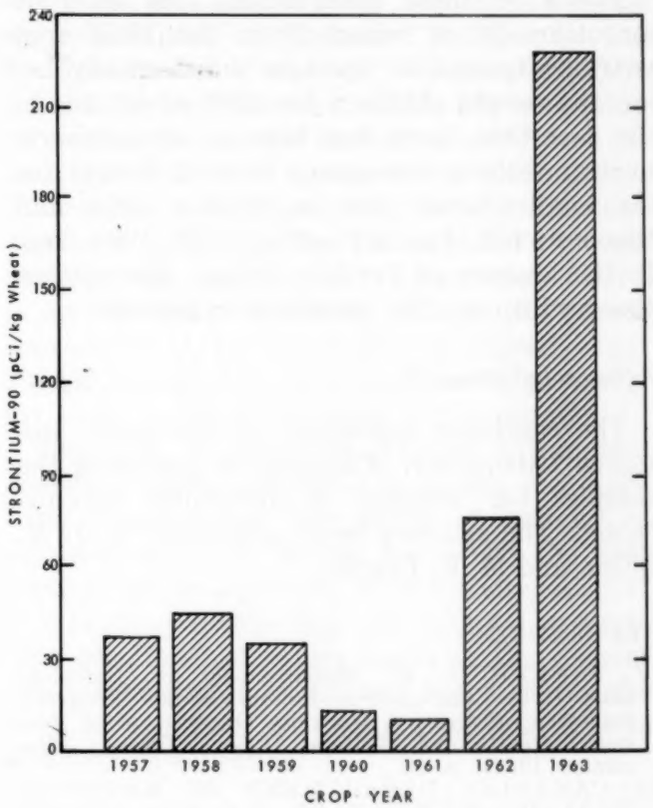

Figure 2. Strontium–90 in Canadian wheat, 1957–1963 (pCi/kg wheat)

It has been well established that strontium–90 enters the wheat grain either through root uptake from the soil or through direct deposition of fallout on the foliar surfaces. Results of analyses on wheat through the years (*1,7*) seem to suggest that direct deposition of fallout on the growing plant is the more important source of contamination during periods of heavy fallout. Taniguchi (*1*) reported a significant decrease in the strontium–90 levels of Canadian wheat from 1959 through 1961 in spite of the fact that there was a gradual increase in the cumulative deposit of strontium–

90 in the soil. This decrease is clearly shown in figure 2. Furthermore, the degree of contamination of wheat by direct deposition on the above ground parts of the plant is most likely determined by the fallout rate after emergence of the wheat ears (*8*). The marked increase in strontium–90 concentration of 1963 wheat can therefore be largely attributed to the extensive atmospheric testing which was conducted in late 1962, since this testing would result in heavy deposition of fallout during the growing period of the wheat plants in 1963.

Based on these observations, the level of strontium–90 in wheat from the 1964 crop year is expected to decrease substantially below the results obtained for 1963 wheat due to the fact that there has been no atmospheric nuclear testing subsequent to 1962, except for the small Chinese test in October 1964, and this occurred after harvesting of the 1964 crop. In the absence of further testing, the pattern observed up to 1961 should be repeated.

Acknowledgements

The continued assistance of the Grain Research Laboratory, Winnipeg, in providing the samples for analysis is gratefully acknowledged. The analyses were performed by J. M. Quinn and M. E. Lescot.

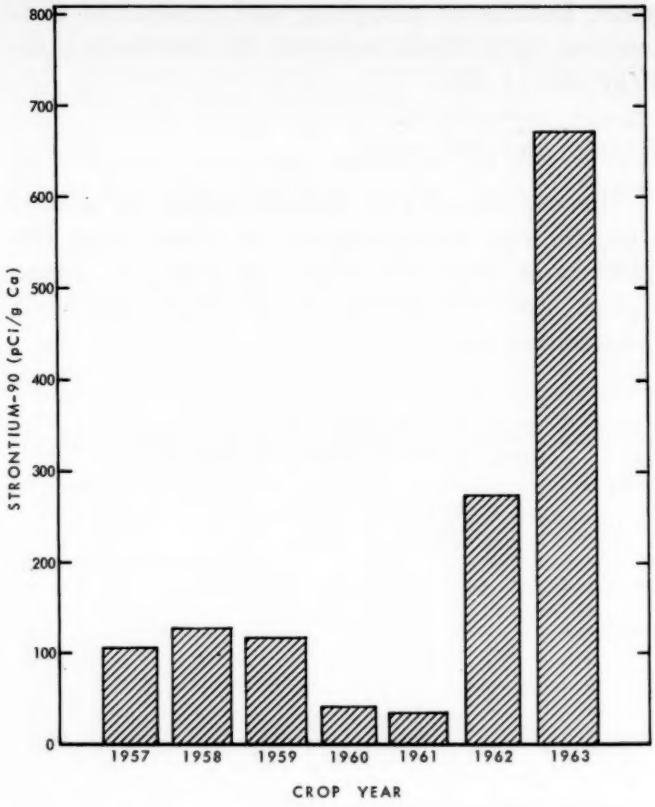

Figure 3. Strontium–90 in Canadian wheat, 1957–1963 (pCi/g Ca)

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Section III—Water

GROSS RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, MARCH 1965

Division of Water Supply and Pollution Control, Public Health Service

Levels of radioactivity in surface waters of the United States have been monitored by the Public Health Service Water Pollution Surveillance System since its initiation in 1957. Beginning with the establishment of 50 sampling points, this system has been expanded to include 131 stations. These stations are operated jointly with other Federal, State, and local agencies, and with private industries. Samples are taken from surface waters of all major U.S. river basins for physical, chemical, biological, and radiological analyses. The system provides background information necessary for recognizing water quality trends and for determining current and general levels of surface water contamination and early detection of specific situations which may warrant more detailed evaluation. Data assembled through the system and exact locations of sampling points are published in annual compilations (*1–8*).

Sampling procedures

The participating agencies collect one-liter "grab" samples each week and ship them "as is" to the Surveillance System Laboratory in Cincinnati for analysis. Gross alpha and gross beta radioactivity determinations on the suspended and dissolved solids are performed as frequently as deemed necessary. Presently, gross alpha and beta determinations are made either on monthly composites of the weekly samples or on each weekly sample. Weekly alpha and beta determinations are scheduled for stations located downstream from known potential sources of radioactive waste. Weekly analyses are conducted at all newly established stations for the first year of operation. Weekly analyses are also scheduled for selected stations in an effort to detect short-term increases in radioactivity from current or recent nuclear tests or events.

Analytical methods

The analytical method for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (*9*). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 micron. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. Reference sources of U_3O_8, which give a known count rate if the instrument is performing properly, are used for daily checking of the counter.

Normally, samples are counted within two weeks following collection or within one week after compositing. The decay of activity is followed for each sample for which the first analysis shows unusually high activity. Also, if a recount indicates that the original analysis was questionable, values based on the recount are recorded. All results are reported for the time of counting and are not extrapolated to the date of collection.

Results

Table 1 presents the most recent results of alpha and beta analysis of U.S. surface waters. The stations on a river are arranged in the table according to their relative location, the first stations listed being closest to the headwaters. These data are preliminary. The figures for gross alpha and gross beta radioactivity represent either determinations on composite samples or means of weekly determinations where composites were not made. The monthly means are reported to the nearest pCi/liter. When all samples have zero pCi/liter, the mean is reported as zero; when the calculated mean is between zero and 0.5, the mean is reported as <1 pCi/liter.

Table 1. Radioactivity in raw surface waters, March 1965

Station	Beta activity, pCi/liter			Alpha activity, pCi/liter		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex.	32	15	47	13	4	17
Arkansas River:						
Coolidge, Kans.	12	39	51	2	27	29
Ponca City, Okla.	27	20	47	8	6	14
Atchafalaya River:						
Morgan City, La.	219	11	230	130	1	131
Bear River:						
Preston, Idaho	0	13	13	0	3	3
Big Horn River:						
Hardin, Mont.	5	20	25	1	12	13
Chena River:						
Fairbanks, Alaska	1	3	4	0	0	0
Clearwater River:						
Lewiston, Idaho	1	4	5	<1	0	<1
Clinch River:						
Clinton, Tenn.	1	4	5	0	0	0
Kingston, Tenn.	6	48	54	0	0	0
Colorado River:						
Loma, Colo.	34	24	58	10	8	18
Page, Ariz.	1	28	29	0	9	9
Parker Dam, Calif-Ariz.	1	18	19	0	6	6
Columbia River:						
Wenatchee, Wash.	1	6	7	0	1	1
Pasco, Wash.	77	309	386	<1	<1	<1
Clatskanie, Ore.	26	81	107	0	1	1
Connecticut River:						
Enfield Dam, Conn.	1	4	5	0	0	0
Coosa River:						
Rome, Ga.	10	5	15	2	0	2
Cumberland River:						
Cheatham Lock, Tenn.	2	5	7	0	0	0
Delaware River:						
Philadelphia, Pa.	4	6	10	1	0	1
Great Lakes:						
Duluth, Minn.	0	2	2	0	0	0
Green River:						
Dutch John, Utah	1	18	19	0	4	4
Hudson River:						
Poughkeepsie, N.Y.	2	9	11	0	0	0
Kansas River:						
De Soto, Kans.	123	18	141	30	3	33
Klamath River:						
Keno, Oreg.	3	9	12	0	<1	<1
Maumee River:						
Toledo, Ohio	9	12	21	2	2	4
Mississippi River:						
St. Paul, Minn.	1	19	20	0	3	3
E. St. Louis, Ill.	28	16	44	5	1	6
New Roads, La.	14	9	23	8	0	8
New Orleans, La.	19	11	30	7	1	8
Missouri River:						
Williston, N. Dak.	4	21	25	0	6	6
Bismarck, N. Dak.	1	22	23	0	5	5
St. Joseph, Mo.	85	24	109	36	3	39
North Platte River:						
Henry, Nebr.	2	35	37	0	32	32
Ohio River:						
Cairo, Ill.	13	8	21	4	0	4
Toronto, Ohio	2	6	8	0	<1	<1
Pend Oreille River:						
Albeni Falls Dam, Idaho	1	4	5	0	1	1
Platte River:						
Plattsmouth, Nebr.	85	19	104	26	2	28
Potomac River:						
Washington, D.C.	4	6	10	1	0	1
Rainy River:						
Baudette, Minn.	1	17	18	0	0	0
Red River, North:						
Grand Forks, N. Dak.	0	23	23	0	1	1
Red River, South:						
Alexandria, La.	23	11	34	4	1	5
Rio Grande:						
El Paso, Tex.	3	18	21	0	7	7
Laredo, Tex.	3	11	14	0	3	3
San Joaquin River:						
Vernalis, Calif.	4	6	10	1	2	3
San Juan River:						
Shiprock, N. Mex.	92	17	109	38	5	43
Savannah River:						
Port Wentworth, Ga.	3	7	10	<1	0	<1
Snake River:						
Wawawai, Wash.	1	7	8	0	2	2
Payette, Idaho	3	10	13	0	2	2
South Platte River:						
Julesburg, Colo.	9	61	70	2	56	58
Tennessee River:						
Chattanooga, Tenn.	2	7	9	0	0	0
Wabash River:						
New Harmony, Ind.	8	10	18	2	1	3
Yellowstone River:						
Sidney, Mont.	9	16	25	2	5	7
Maximum	219	309	386	130	56	131
Minimum	0	2	2	0	0	0

A geographical perspective of the radioactivity in surface water is obtained from the numbers printed near the stations as shown in figure 1, which gives the average total beta activity in suspended-plus-dissolved solids in raw water collected at each station.

It has been observed that in water the natural environmental beta activity is usually several times that of the natural environmental alpha activity. Nuclear installations may contribute additional alpha or beta activity, whereas fallout contributes primarily additional beta activity.

The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes (*10*). The Public Health Service Drinking Water Standards state that in the absence of strontium–90 and alpha emitters,[1] a water supply is acceptable when the gross beta concentration does not exceed 1,000 pCi/liter (*11*).

The rise of radioactivity levels expressed in pCi/liter at a particular station is often presumed to be associated with a corresponding increase in suspended solids. For example, the samples for November 1964 and January, February, and March 1965 from the Atchafalaya River at Morgan City, Louisiana, have shown increased alpha and beta activities in suspended solids when compared to results of other recent months. In order to verify and understand the meaning of these results, several steps were taken. Data from the nearest

[1] Absence is taken here to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha emitters and strontium–90, respectively.

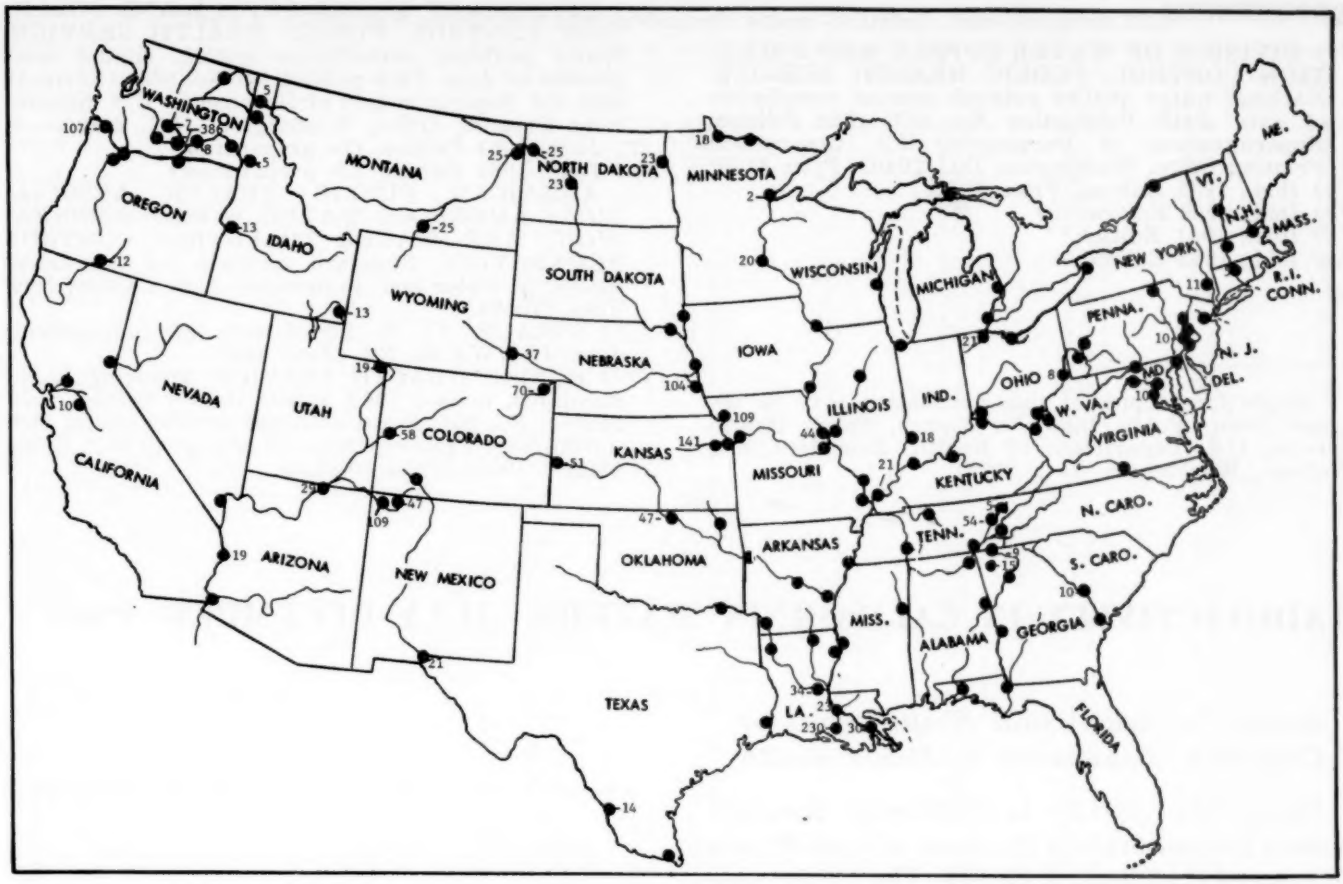

Figure 1. Sampling locations and associated total beta activity (pCi/liter) in surface waters, March 1965

upstream station (Alexandria, Louisiana) were also examined. The volumetric radioactivity in pCi/liter was converted to specific radioactivity in pCi/g of suspended solids. The average results over a six-month period from October 1964 through March 1965 yielded average specific alpha activities of 45 pCi/g of suspended solids for each station and average specific beta activities of 59 pCi/g of suspended solids for each station. During the same period, the average volumetric alpha activity was 60 pCi/liter and the average beta activity was 185 pCi/liter for suspended solids.

A three-month composite sample from Morgan City, Louisiana, which had been made up of weekly samples collected from October 1964 through December 1964 was analyzed in triplicate in order to verify the validity of the monthly determinations. The average specific alpha activity on suspended solids was 37 pCi/g and the average specific beta activity on suspended solids was 45 pCi/g. For comparison, the average volumetric alpha activity on suspended solids was 53 pCi/liter and the average volumetric beta activity on suspended solids was 147 pCi/liter. The agreement between determinations was excellent and agreement with the six-month averages at Morgan City, Louisiana, and Alexandria, Louisiana, was reasonable.

Although noticeable variations occurred in the volumetric radioactivity values, the specific radioactivity values in pCi/g of suspended solids did not show the same degree of change. Thus, the rise observed in the Atchafalaya River data presented in pCi/liter is obviously associated with the level of suspended solids in the water. In table 1 the following stations show relatively high values for alpha and beta radioactivity because of parallel high suspended solids: Morgan City, Los Angeles, De Soto, St. Joseph, Plattsmouth, and Shiprock. The dissolved solid levels in comparison to alpha and beta activity also show the same pattern, but in lesser degree.

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RADIOACTIVITY IN CALIFORNIA WATERS,[1] JULY–DECEMBER 1964

Bureau of Radiological Health, State of California, Department of Public Health

Gross beta activity in California domestic waters is monitored by the State of California's Bureau of Radiological Health. The importance of this program in the State's environmental surveillance activities stems from the fact that most of California's domestic water supplies are of surface origin.

Radioactivity in such water supplies consists of the natural radioactivity in surface streams, radioactivity added by the discharge of sewage or by industrial waste effluents, and radioactivity from fallout, particularly fallout into open terminal or distribution reservoirs. Present efforts consist of sampling raw and treated surface waters, and well waters. It should be noted that except for large metropolitan water supplies, raw water sampling is being phased out and treated water sampling is being substituted or continued. This procedural change is predicted upon sampling water at the point of consumption.

Most of the supplies sampled have as a source, raw surface waters (figure 1), although a few wells, along with some water supplies that use infiltration galleries, are also sampled.

Figure 1. California surface water sampling stations

Monitoring of domestic water supplies is on a continuing basis, since it has not been possible to forecast levels of radioactivity in these supplies based upon levels in rain, snow, or

[1] Data from "Radiological Health News," Vol. 4, No. 1 (January 1965), No. 2 (April 1965). California Department of Public Health, Bureau of Radiological Health, 2151 Berkeley Way, Berkeley 4, California.

Table 1. Gross beta activity in California domestic waters (pCi/liter), July–December 1964

Sampling station	Quality	July	August	September	October	November	December
Alturas	Well	[a] 16.2	[a] 6.8	NS	NS	[a] 8.9	[a] 4.9
Antioch	Raw	NS	ND	ND	[a] 6.3	ND	[a] 8.3
	Treated	NS	[a] 6.4	[a] 1.5	ND	[a] 2.7	[a] 0.8
Arrowhead Lake	Treated	[a] 2.5	NS	[a] 14.2	NS	30.6	NS
Berkeley	Treated	[a] 5.1	[a] 2.9	[a] 19.1	[a] 11.6	[a] 5.6	NS
Clearlake Highlands	Raw	ND	[a] 9.3	[a] 7.4	[a] 12.0	[a] 10.1	[a, b] 15.8
Crescent City	Raw	[a] 8.1	ND	ND	[a] 2.6	[a] 1.6	[a] 8.3
Death Valley	Treated	NS	NS	NS	NS	NS	ND
Dos Palos	Treated	[a] 5.8	ND	[a] 0.8	[a] 1.3	[a] 7.1	[a] 9.4
El Centro	Raw	[a] 13.5	ND	NS	NS	NS	NS
	Treated	[a] 2.7	ND	[a] 14.6	[a] 15.0	[a] 9.6	[a] 26.0
Eureka	Raw	[a] 2.4	ND	ND	ND	[a] 1.6	[a] 12.5
	Treated	[a] 15.8	[a] 1.4	[a] 0.7	[a] 15.0	[a] 7.9	ND
Fort Bragg	Raw	ND	ND	[a] 0.9	NS	NS	[a] 8.0
Los Angeles Laboratory	Treated	[a, b] 14.4	NS	[a, b] 4.8	ND	NS	[a] 9.0
Marin Municipal Water District:							
Corte Madera	Treated	[a] 5.3	[a] 5.0	NS	[a] 13.6	[a] 2.4	NS
Mariposa	Raw	[a] 18.1	23.0	NS	ND	[a] 7.2	NS
Metropolitan Water District of Southern California:							
Lake Havasu	Raw	NS	[a] 9.6	[a] 8.8	[a] 7.1	[a] 2.3	NS
Lake Matthews	Raw	ND	[a] 4.3	[a] 2.4	[a] 22.7	[a] 19.6	NS
Lake Millerton	Raw	[a] 19.6	[a] 8.1	[a] 15.4	[a] 13.0	NS	[a] 8.3
Monterey	Raw	ND	[a] 1.3	ND	[a] 4.1	NS	[a] 8.1
Napa	Raw	[a, b] 8.5	[a, b] 3.6	NS	NS	[a] 12.2	[a] 2.6
Needles	Treated	[a] 12.8	NS	NS	NS	NS	NS
North Marin Water District	Well	[a] 18.5	[a] 2.4	ND	[a] 7.2	[a] 17.3	ND
	Raw	[a] 0.7	[a] 5.7	[a] 14.9	[a] 10.9	[a] 13.6	[a] 8.9
	Sludge	17.0	71.6	[a] 25.6	[a] 34.2	[a] 53.0	[a] 102.4
Oroville:							
Wyandotte Irrigation District	Raw	[a] 6.2	[a] 9.6	[a] 12.4	NS	[a] 2.0	[a] 1.7
California Water Service	Raw	NS	ND	NS	[a] 0.5	NS	[a] 11.2
Placerville	Raw	NS	NS	NS	NS	NS	NS
Redding	Raw	[a] 17.1	[a] 7.5	[a] 11.0	56.3	5.6	[a] 3.4
Sacramento	Raw	[a] 5.0	[a] 3.9	ND	[a] 2.7	[a] 3.3	NS
San Diego	Treated	[a] 8.5	[a] 25.5	ND	33.9	[a] 8.1	NS
San Francisco:							
Water Department	Treated	ND	[a] 3.2	NS	NS	ND	NS
Alameda, East	Treated	[a] 15.1	57.7	NS	[a] 16.2	24.7	NS
Brightside Weir	Raw	ND	[a] 5.3	NS	ND	ND	NS
Calaveras Reservoir	Raw	[a] 8.4	93.4	NS	ND	[a] 7.8	NS
Crystal Springs	Raw	[a] 3.1	NS	NS	NS	NS	NS
Crystal Springs Line No. 1	Raw	NS	[a] 13.5	NS	[a] 15.3	ND	NS
Crystal Springs Line No. 2	Raw	NS	NS	NS	NS	NS	NS
Hetch Hetchy	Raw	42.7	NS	[a] 7.2	NS	[a] 14.3	[a] 14.1
Moccasin	Raw	NS	NS	NS	NS	NS	NS
San Andreas Line No. 1	Raw	NS	NS	NS	NS	NS	NS
San Jose	Raw	ND	ND	[a] 8.5	NS	NS	ND
San Luis Obispo	Raw	[a] 8.4	[a] 4.3	[a] 5.7	NS	29.1	[a] 5.2
Santa Barbara	Raw	[a] 15.6	ND	[a] 7.6	[a] 8.2	ND	[a] 11.0
Santa Cruz	Coastal	ND	NS	ND	NS	ND	NS
	Raw	[a] 6.3	ND	ND	[a] 7.2	NS	ND
	Treated	ND	[a] 6.4	[a] 6.0	ND	NS	[a] 13.8
Santa Rosa	Raw	[a] 13.3	[a] 6.9	ND	ND	[a] 5.4	ND
	Treated	ND	[a] 6.6	[a] 5.9	7.0	[a] 4.9	ND
Scotia	Raw	[a] 14.2	ND	ND	[a] 11.0	45.6	NS
	Treated	NS	NS	NS	NS	NS	[a] 2.6
Tahoe City	Raw	[a] 12.5	NS	NS	NS	ND	NS
Ukiah	Well	[a] 1.6	[a] 8.7	ND	ND	ND	ND
Vallejo:							
Fleming Hill	Raw	[a] 13.0	[a] 5.4	NS	ND	ND	NS
	Treated	[a] 10.3	ND	[a] 3.0	[a] 0.5	[a] 4.8	NS
Swanzy Reservoir	Raw	[a] 0.4	[a] 6.8	[a] 14.0	[a] 11.4	[a] 5.0	NS
Willits	Raw	ND	ND	ND	ND	[a] 11.7	[a] 11.8
Yosemite	Raw	22.7	7.0	[a] 14.6	[a] 8.9	[a] 13.9	[a] 10.6
Maximum		42.7	57.7	25.6	56.3	53.0	102.4
Minimum		0	0	0	0	0	0

[a] When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best estimate, but is not statistically significant.

[b] Average of more than one sample for the month.

Key to Symbols: ND—Non-detectable
NS—No sample collected

surface streams. Under the present sampling schedule, monthly 500–ml samples are collected and the total solids analyzed for alpha and beta radioactivity. In addition, three-liter samples are collected monthly for approximately six months and composited for specific radionuclide analysis on a biannual basis.

Analytical procedures

Radionuclide analyses of water are carried out in the State's Sanitation and Radiation Laboratory. Measurements of alpha and alpha-plus-beta activities are made with a low-background windowless gas-flow proportional

counter. Counting methods used are in accordance with U.S. Public Health Service recommended procedures (*1*).

Individual samples are evaporated down to dryness and the residue ashed at 450°C. The ashed sample is dissolved and transferred to an aluminum planchet for beta counting. Gamma-emitting radionuclides are determined biannually on the composite samples.

Discussion

Table 1 shows the monthly average beta activity in the suspended-plus-dissolved solids in raw surface water in California from July through December 1964. Following treatment, these waters are used for industrial and domestic purposes. Because alpha activity in water has in general been undetectable or very slight, alpha activity analyses are not presented. Little increase in the radioactivity level of surface water has been observed in spite of some increase in fallout.

REFERENCES

(*1*) DIVISION OF RADIOLOGICAL HEALTH. Radionuclide analyses of environmental samples, R 59–6. Radiological Health Research Activities, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio 45226 (November 16, 1959).

Recent coverage in *Radiological Health Data:*

Period	Issue
1961–June 1962	*April 1963*
July–December 1962	*September 1963*
January–June 1963	*March 1964*
July–December 1963	*September 1964*
January–June 1964	*March 1965*

RADIOACTIVITY IN NEW YORK SURFACE WATER JUNE–DECEMBER 1964

Division of Environmental Health Services
State of New York Department of Health

The New York Department of Health began a program in 1953 to determine the amount of radioactivity in water used for public consumption. This radioactivity in water may arise from the natural mineral content of water (background), from atmospheric fallout, and from nuclear industry operations. Water samples are obtained from 26 locations for gross beta analysis (figure 1). Table 1 gives the sampling frequency and type of sample. Larger size samples are collected at selected locations for strontium–90 analyses.

Analytical procedures

Beta activity concentrations are determined by evaporating a known volume of water to dryness and counting in an end-window, gas-flow proportional counter.

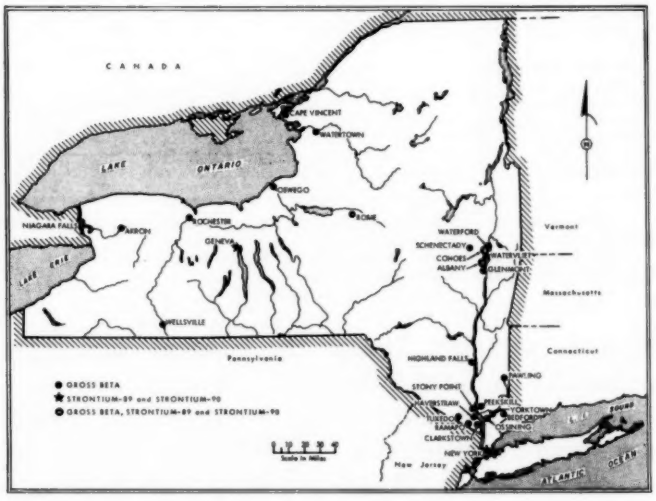

Figure 1. New York water sampling locations

Table 1. Gross beta activity concentrations in New York raw surface water, July–December 1964

Location	Sampling	Concentration pCi/liter					
		July	August	September	October	November	December
Akron (Murder Creek)	BW	12	12	11	9	9	10
Bedford (Byram Lake)	M	4		9	10	13	8
Cape Vincent (St. Lawrence River)	M				5		
Clarkstown (Congers Lake)	M	22		20			
Clarkstown (Lake De Forest)	M	11		11		8	6
Cohoes (Mohawk River)	C	6		8	9	8	6
Glenmont (Hudson River)	D	8		8	7	8	6
Haverstraw (Letchworth V. Res.)	M	6		5		2	6
Highland Falls (Bog Meadow Brook)	M	4		4	5	6	5
Niagara Falls (W. Branch Niagara River)	M			7		3	
Niagara Falls (E. Branch Niagara River)	M			9		4	
Ossining (Hudson River) (Sing Sing)	BW	57	64	61	66	60	62
Ossining (Indian Brook Res.)	M	17		12	7	6	7
Oswego (Lake Ontario)	W			7	5	5	5
Pawling (Pond at United Nuclear)	M	4		8	3	5	
Peekskill (Hudson River)	W	28		43	48	51	44
Peekskill (Camp Fields WS)	W	10		6	5	4	7
Ramapo (Hillburn WS)	M	7		5		2	
Rome (Fish Creek)	BW	8		8	5	6	8
Schenectady (Mohawk River)	C	11		8	8	6	6
Stony Point (Iowa Is. W.S.)	M	2		3		3	3
Tuxedo (Indian Kill Outfall)	C			10	11	10	11
Waterford (Hudson River)	BW	10		7	6	5	5
Watertown (Black River)	M	8		9	7	8	7
Watervliet (Fr. Mills Res.)	M	5		5	5	5	5
Yorktown (Croton Res.)	W	13		9	9	8	6

Key to symbols: BW—Biweekly composite of daily grab samples
M—Monthly grab sample
C—Continuous bleed-off analyzed weekly
D—Weekly composite of daily grab samples
W—Weekly grab sample
Blanks indicate no sample collected

For strontium–89 and strontium–90 determinations, a measured volume of water is passed through an ion exchange column. The radiostrontium is complexed on the resin as strontium sulfate. The strontium is then eluted from the resin. The resultant solution is concentrated and subsequently counted in a low background, end-window, gas-flow proportional counter. Successive countings at two day intervals facilitate the determination of the strontium–90 and strontium–89 concentrations.

Table 2. Strontium-89 concentrations in New York water, June–December 1964

Sampling location	Radionuclide concentration, pCi/liter						
	June	July	Aug	Sept	Oct	Nov	Dec
Albany	<3	<3	NS	<3	<3	<3	<3
Cohoes	<3	<3	<3	NA	<3	<3	<3
Geneva	<3	<3	<3	<3	6	<3	<3
New York City	<3	<3	NS	<3	<3	<3	<3
Additional sites:							
Ashford	—	—	—	—	<3	<3	<3
East Otto	—	—	—	<3	<3	<3	<3
Ellicottville	—	—	—	<3	<3	NS	<3
Franklinville	—	—	—	<3	<3	<3	<3

Key to symbols: NA—No analysis
NS—No sample collected
— Station not in operation

Discussion and results

The observed gross beta activity concentrations in New York surface water for July–December 1964 are given in table 1. It is of interest to note that the Cohoes gross beta results are for a raw water sample, while the Cohoes radiostrontium results are for a finished water.

The observed strontium–89 and strontium–90 concentrations in New York water for June through December 1964 are presented in tables 2 and 3.

Table 3. Strontium-90 concentrations in New York water, July–December 1964

Sampling location	Radionuclide concentration, pCi/liter					
	July	Aug	Sept	Oct	Nov	Dec
Albany	<3	<3	NS	<3	<3	3
Cohoes	<3	4	<3	NA	5	<3
Geneva	<3	<3	<3	<3	<3	<3
New York City	<3	5	NS	<3	<3	<3
Additional sites:						
Ashford	—	—	—	<3	<3	<3
East Otto	—	—	<3	5	<3	<3
Ellicottville	—	—	<3	<3	NS	<3
Franklinville	—	—	<3	6	<3	<3

Key to symbols: NA—No analysis
NS—No sample collected
— Station not in operation

Section IV—Other Data

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Summaries of the environmental radioactivity data for 22 AEC installations have appeared periodically in *RHD* since November 1960. Summaries follow for the Argonne National Laboratory, Atomics International, and the National Reactor Testing Station.

Releases of radioactive materials from these installations for the periods covered in the reports below are governed by radiation protection standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1] These standards, which include radioactivity concentrations limits, are applicable to effluents released from AEC installations.

1. Argonne National Laboratory[2] July–December 1964

University of Chicago
Lemont, Illinois

The radioactivity of the environment at and near Argonne National Laboratory (ANL) is determined on a continuing basis by measuring the radioactivity levels in air, water, and raw milk. The sampling locations for air and water are shown in figures 1 and 2.

[1] Part 20, "Standards for Protection Against Radiation," AEC Rules and Regulations, contains essentially the standards published in the "AEC Manual." The AEC Rules and Regulations are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, on a subscription basis at $3.50 for 3 years.

[2] Summarized from "Environmental Radioactivity at Argonne National Laboratory, July–December 1964," University of Chicago, Lemont, Illinois.

Air monitoring

Air filter samples are collected continuously at seven locations on the Argonne site and at five locations off the site. The total alpha and beta activities are summarized in table 1. The data show little difference between offsite and onsite measurements, indicating that ANL does not contribute more than negligible quantities of radioactive materials to the atmosphere.

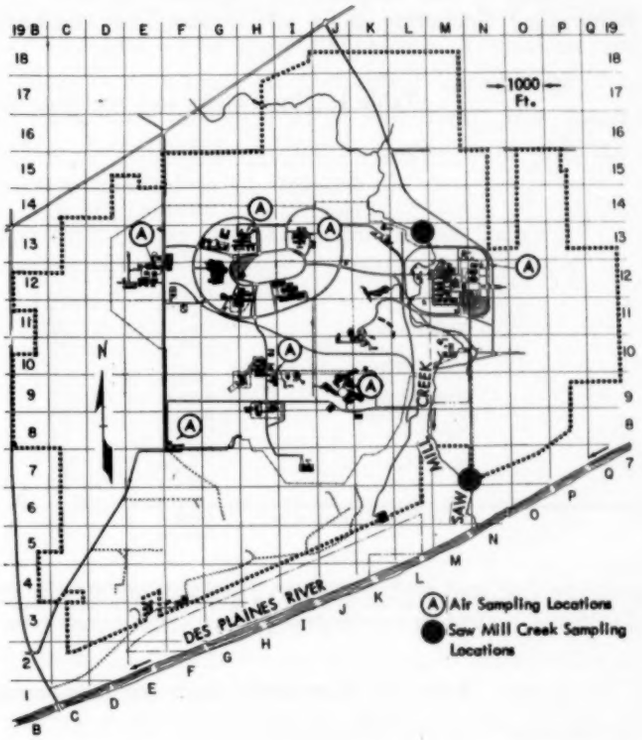

Figure 1. Onsite sampling locations, Argonne National Laboratory

Water monitoring

ANL waste water is discharged into Sawmill Creek, a stream that runs through the Argonne grounds and enters the Des Plaines River about 500 yards downstream from the waste water discharge to evaluate the effect of the waste water on the radioactivity in the Creek.

Figure 2. Site locations of Argonne National Laboratory (including some offsite sampling stations)

On Sawmill Creek, the upstream flow is roughly equal to the waste water flow, yielding a twofold dilution. The data in table 2 show significantly higher concentrations downstream from the waste water discharge, an indication of the radioactivity contributed to the stream by ANL. Nevertheless, a comparison of the downstream concentrations with permissible environmental concentrations shows that all concentrations are relatively low.

Samples are collected from the Des Plaines River upstream and downstream from its junction with Sawmill Creek. The results shown in tables 2 and 3 indicate that dilution by the Des Plaines River is large enough to reduce radioactivity contributed from ANL to undetectable levels.

Milk monitoring

Three samples of raw milk produced in the area are analyzed monthly for a number of

Table 1. Total alpha and beta activities in air filter samples, July–December 1964[a]

(pCi/m³)

Period	Location	No. of Samples	Alpha activity			Beta activity		
			Average	Minimum	Maximum	Average	Minimum	Maximum
July	Onsite	30	0.0032	0.0010	0.0058	1.0	0.6	1.8
	Offsite	23	0.0038	0.0025	0.0056	1.0	0.7	1.7
August	Onsite	24	0.0028	0.0018	0.0043	0.6	0.4	0.8
	Offsite	22	0.0033	0.0022	0.0048	0.6	0.5	0.9
September	Onsite	27	0.0027	0.0015	0.0050	0.3	0.2	0.5
	Offsite	23	0.0027	0.0013	0.0049	0.3	0.2	0.5
October	Onsite	23	0.0037	0.0015	0.0060	0.4	0.2	0.9
	Offsite	22	0.0038	0.0021	0.0077	0.4	0.2	0.7
November	Onsite	24	0.0043	0.0024	0.0075	0.5	0.2	1.3
	Offsite	20	0.0040	0.0019	0.0086	0.5	0.2	1.2
December	Onsite	26	0.0037	0.0024	0.0053	0.2	0.1	0.3
	Offsite	22	0.0043	0.0026	0.0057	0.2	0.2	0.3
July-December summary	Onsite	154	0.0034	0.0010	0.0075	0.5	0.1	1.8
	Offsite	132	0.0037	0.0013	0.0086	0.5	0.2	1.7

[a] These results were obtained by measuring the samples four days after they were collected in order to avoid counting the natural radioactivity due to radon and thoron decay products. This activity is normally present in the air and disappears within four days by radioactive decay.

Table 2. Nonvolatile alpha and beta activity in Sawmill Creek water, July–December 1964

Period	Location	No. of Samples	Alpha activity, pCi/liter			Beta activity, pCi/liter		
			Average	Minimum	Maximum	Average	Minimum	Maximum
July	Upstream	5	1.1	0.4	1.5	26	16	34
	Downstream	15	1.4	0.8	2.2	177	10	593
August	Upstream	4	0.8	0.6	1.0	11	10	12
	Downstream	12	0.4	1.1	2.4	222	41	754
September	Upstream	5	1.0	0.2	2.1	16	7	32
	Downstream	12	2.0	1.1	3.7	93	39	218
October	Upstream	4	1.9	0.3	2.9	13	8	20
	Downstream	15	3.6	1.7	8.3	43	26	66
November	Upstream	4	1.8	1.5	2.2	13	7	17
	Downstream	12	3.2	1.6	4.7	26	17	29
December	Upstream	3	2.2	1.8	2.7	18	13	24
	Downstream	15	2.4	1.3	4.1	22	20	27
July-December summary:	Upstream	25	1.5	0.2	2.9	16	7	34
	Downstream	81	2.3	0.8	8.3	96	10	754

Table 3. Nonvolatile alpha and beta activity in Des Plaines River water, July–December 1964

Period	Location	No. of Samples	Alpha activity, pCi/liter			Beta activity, pCi/liter		
			Average	Minimum	Maximum	Average	Minimum	Maximum
July	Upstream	5	1.9	0.3	3.7	37	31	46
	Downstream	5	1.8	0.8	2.5	34	33	37
August	Upstream	4	3.3	2.0	7.0	41	33	57
	Downstream	4	2.1	0.8	3.9	29	26	34
September	Upstream	5	1.8	1.0	2.6	29	25	36
	Downstream	5	2.3	1.4	3.1	31	25	40
October	Upstream	4	3.2	2.9	3.4	31	26	34
	Downstream	4	1.9	1.5	2.3	26	21	31
November	Upstream	4	2.0	1.2	2.5	38	20	59
	Downstream	4	1.6	0.9	2.6	29	24	31
December	Upstream	2	2.3	2.3	2.3	22	21	23
	Downstream	5	2.1	0.5	3.1	21	18	27
July-December summary:	Upstream	24	2.4	0.3	7.0	33	20	59
	Downstream	27	2.0	0.5	3.9	29	18	40

fission products. Only the long-lived fission products, cesium–137 and strontium–90, have been detected. The concentrations of these two nuclides are shown in table 4. These activities are due to fallout from nuclear detonations and are not related to Argonne operations.

Table 4. Cesium-137 and strontium-90 in raw milk, July–December 1964

Date collected	Cesium-137, pCi/liter		Strontium-90, pCi/liter	
	Average	Maximum	Average	Maximum
July 3	330	360	15	17
August 7	195	200	15	16
September 4	155	205	13	14
October 2	120	155	11	13
November 17	130	140	13	16
December 9	200	215	14	16

Summary

Argonne's contribution to environmental radioactivity is generally confined to Sawmill Creek below the waste water discharge. Radioactivity originating at Argonne was not found in any other material or at any other location off the site. The concentrations of radioactive substances added to the environment by Argonne were considerably less than the maximum permissible concentrations and did not constitute a health hazard.

Recent coverage in *Radiological Health Data:*

Period	Issue
Second half 1960	*July 1961*
First half 1961	*December 1961*
Second half 1961	*May 1962*
Calendar year 1962	*May 1963*
Calendar year 1963	*August 1964*
First half 1964	*March 1965*

2. Atomics International[3] July–December 1964

North American Aviation, Incorporated
Canoga Park, California

Atomics International, a division of North American Aviation, Incorporated, operates the Nuclear Development Field Laboratory (NDFL) and the World Headquarters Facility (WHF) at Canoga Park, California, under contract with the Atomic Energy Commission. The company designs, develops, and constructs nuclear reactors for central station and compact power plants, and for medical, industrial, and scientific application. Locations of the facilities are shown in figure 3.

The NDFL facilities include a 20-megawatt sodium reactor experiment (SRE) power reactor, several smaller experimental reactor facilities and extensive rolling and fuel fabrication operations. The WHF is primarily an administrative building, but a small amount of fuel fabrication is conducted there. For this reason, the WHF area is included in the environmental monitoring.

Environmental monitoring is conducted at WHF and NDFL to test the effectiveness of the Company's radiological safety procedures

[3] Summarized from "Environmental Monitoring, Semiannual Report, July 1, 1964 to December 31, 1964," Atomics International.

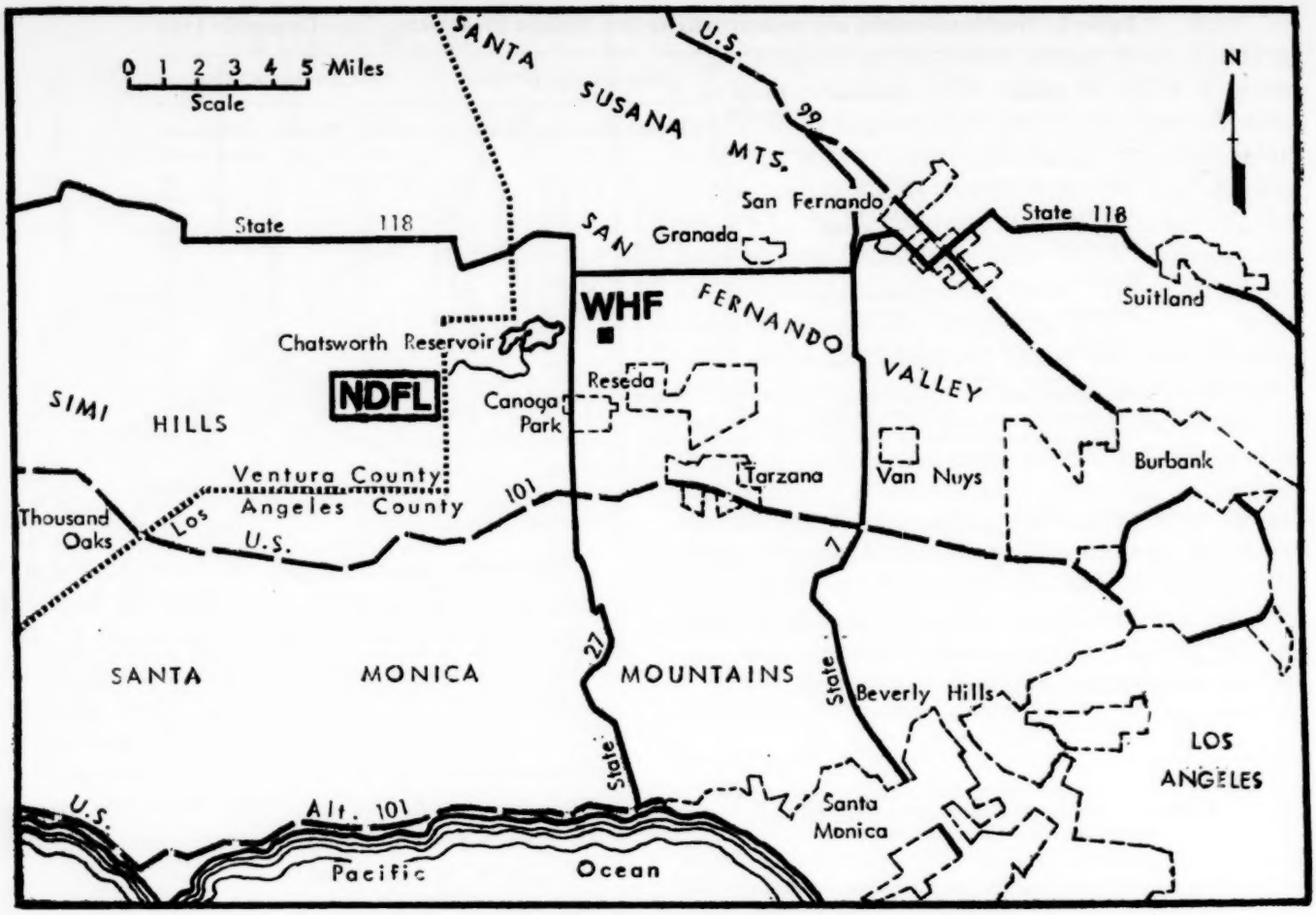

Figure 3. Atomics International facilities and vicinity

and of engineering safeguards incorporated into the facility. This program consists of periodic sampling of air, water, soil, and vegetation in the environs of these two installations.

Air monitoring

Environmental air sampling is conducted continuously with automatic air samplers operating on 24-hour sampling cycles. Airborne particulate radioactivity is collected on a stationary filter tape which is automatically changed at the end of each sampling period. The filter tape is removed, allowed to decay for 72 hours and counted in an automatic proportional counting system. The volume of a typical daily air sample is approximately 21 cubic meters. Airborne radioactivity concentrations remained low with little daily variation. The average concentration of beta and gamma activity at Canoga Park during the second half of 1964 was 0.71 pCi/m^3.

Water monitoring

Process water at the NDFL is obtained from wells and stored in 50,000-gallon tanks. Monthly samples are collected from these wells. Potable water is obtained in bottles delivered to the site and is, therefore, not analyzed. Process water is drawn from the wells into one-liter polyethylene bottles for transfer to the laboratory, as are water samples from the lake surface and supply inlet of Chatsworth Reservoir. The results from the analysis of all water samples are shown in table 5. In some cases the

Table 5. Radioactivity in water samples July–December 1964

Source	Average activity (pCi/liter)	
	Alpha	Beta-gamma
NDFL wells	0.22	6.8–7.0
Chatsworth Reservoir surface	0.83	8.8
Chatsworth Reservoir supply inlet	0.59	7.8

average concentration is presented as a range. A range is recorded when one or more of the samples analyzed contains an undetectable amount of radioactivity. The lower value is obtained by assuming that the "undetectable" samples contain no radioactivity; the higher, by assuming that these samples contain radioactivity equal to the appropriate minimum detection limit.

Soil and vegetation monitoring

Soil and vegetation are sampled monthly. Surface soil samples are collected from the top half-inch layer of ground surface. The results from soil analysis are shown in table 6.

Table 6. Radioactivity in soil samples July–December 1964

Area	Average activity (pCi/g)	
	Alpha	Beta-gamma
Onsite	0.54–0.55	29
Offsite	0.45–0.49	19

Vegetation samples obtained in the field are of the same plant type wherever possible—generally sunflower or wild tobacco plant leaves. These types maintain a more active growth rate during the dry season than does most natural vegetation indigenous to the local area. These samples are washed and ashed before analysis. The results from vegetation analysis are shown in table 7.

Table 7. Radioactivity in vegetation samples July–December 1964

Area	Average activity (pCi/g ash)	
	Alpha	Beta-gamma
Onsite	0.61–0.62	175
Offsite	0.63–0.64	130

Recent coverage in *Radiological Health Data:*

Period	Issue
Calendar year 1960 and first half 1961	*December 1961*
Second half 1961	*August 1962*
Calendar year 1962	*November 1963*
Calendar year 1963	*September 1964*
First half 1964	*March 1965*

3. National Reactor Testing Station[4] July–December 1964

Idaho Falls, Idaho

The National Reactor Testing Station (NRTS) is located in a very remote area, which permits controlled releases of radioactivity from the projects with minimum hazard to sizable population groups. The NRTS surveillance program is conducted by the AEC's Idaho Operations Office. The monitoring program consists of periodical sampling of ground and surface waters, milk, air, and wheat. The locations at which these samples are taken are shown in figure 4. The results of the analysis of these samples, with the exception of wheat (not sampled during this period), are shown in table 8.

Offsite well water monitoring

Low-level liquid wastes resulting from operation of the various facilities at the NRTS are released to the ground-water table through disposal wells and ponds located near each facility. Although liquid wastes are monitored at the NRTS before disposal, offsite underground samples are collected regularly. Most of these samples are taken from an area southwest of the NRTS since this is the prevalent direction of underground water flow. During the second half of 1964, the average concentrations of alpha and beta emitters were no more than 40 percent and 0.3 percent respectively of the applicable concentration guides. The alpha activity is attributed primarily to radioactive elements which are naturally present in the environment.

Onsite well water monitoring

Onsite samples were taken from the plant production wells in order to monitor potable water for detection and definition of possible sources of contamination. Analyses of these

[4] Summarized from "Environmental Monitoring Report No. 15, Third and Fourth Quarter and Annual Summary 1964." U.S. Atomic Energy Commission, Idaho Operations Office, Health and Safety Division, National Reactor Testing Station.

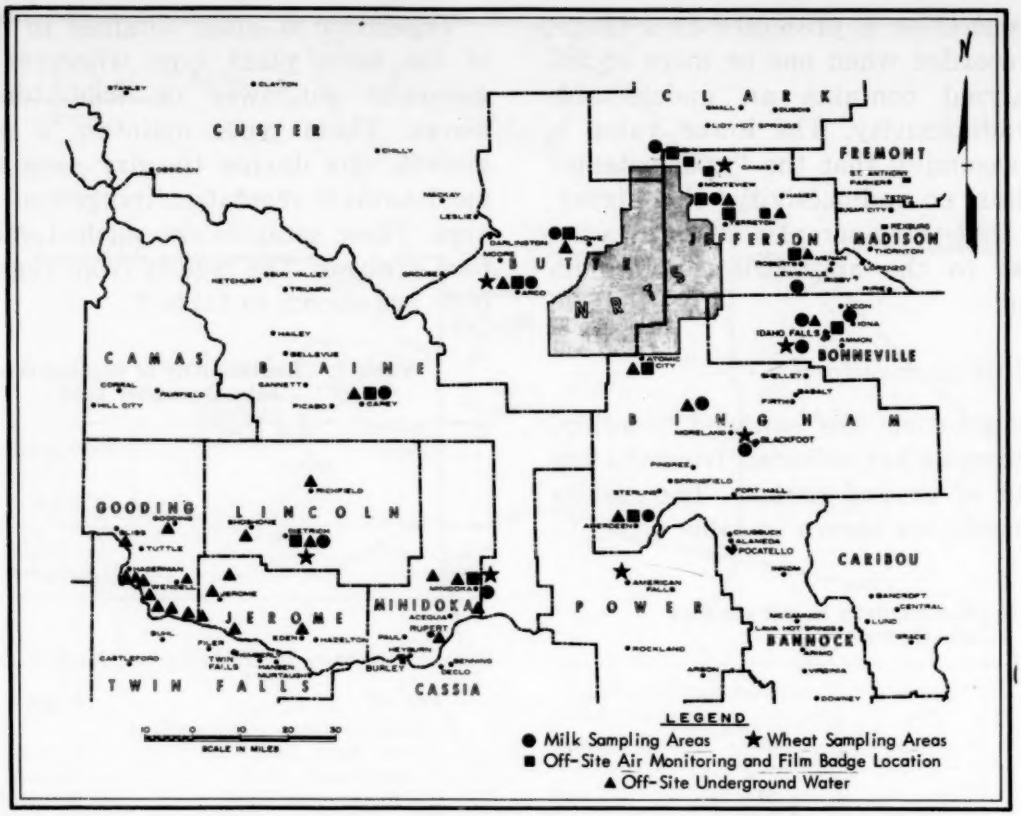

Figure 4. Environmental monitoring stations, National Reactor Testing Station

Table 8. Environmental monitoring data for the National Reactor Testing Station, July–December 1964

Type of sample	Number of stations	Approximate frequency of collection	Total number of samples	Maximum activity	Average activity per sample	Applicable concentration guides
Offsite well water	32	Semiannual	32	α:4 x 10^{-3} pCi/ml β:2 x 10^{-2} pCi/ml	α: <4 x 10^{-3} pCi/ml β: <1 x 10^{-2} pCi/ml	α:10 x 10^{-3} pCi/ml β:300 x 10^{-2} pCi/ml
Onsite well water	22	Two weeks	237	α:5 x 10^{-3} pCi/ml β:8 x 10^{-2} pCi/ml	α: <4 x 10^{-3} pCi/ml β: <1 x 10^{-2} pCi/ml	α:100 x 10^{-3} pCi/ml β:3000 x 10^{-2} pCi/ml
Offsite air	15	Continuous		Particulate β-γ: 37 x 10^{-6} pCi/ml	Particulate β-γ: <5 x 10^{-6} pCi/ml	Particulate β-γ: 100 x 10^{-6} pCi/ml
				Gaseous iodine: 5 x 10^{-6} pCi/ml	Gaseous iodine: <4 x 10^{-6} pCi/ml	Gaseous iodine: 100 x 10^{-6} pCi/ml
Offsite milk	14	Monthly	80	Iodine-131: <20 pCi/liter	Iodine-131: <20 pCi/liter	Iodine-131: 100 pCi/liter
Offsite area monitoring badges	11	Monthly	* 73	Strontium-90: 26 pCi/liter	Strontium-90: 16 pCi/liter	Strontium-90: 200 pCi/liter
	14	Quarterly	27	γ: 150 mR/yr β: <40 mrad/yr	γ: 80 mR/yr β: 40 mrad/yr	γ: 500 mR/yr β: 3000 mrad/yr

* Total samples analyzed for strontium-90 include month of June 1964.

samples showed that average concentrations of alpha and beta emitters were no more than 4 percent and 0.1 percent of their respective guide values.

Offsite air monitoring

During 1964, data reported electronically from the radiation monitoring telemetry system replaced data previously derived manually from offsite air samples collected by means of a dual filter and a low-volume vacuum pump. The telemetry system has many operating capabilities not available in the previous system. Normal operations call for hourly reports by each station. These reports include information from:

Ion chambers: These instruments measure ambient radiation levels in mr/hr.

GM counters: HV–70 filter paper is cycled to a GM tube once a day. One GM tube measures the buildup of particulate activity over the day and another measures the decay of the activity collected the previous day.

Scintillation counter: Air which has previously passed through the HV–70 particulate filter then passes through a carbon cartridge. For surveillance purposes, the activity measured is assumed to be iodine–131. This cartridge remains in place for periods up to 6 weeks.

Results of the data reported from the 15 telemetry stations indicate that the sum of the average concentration of gaseous iodine–131 and particulate activity in the atmosphere was no greater than 9 percent of the applicable concentration guide of 100×10^{-6} pCi/ml.

Offsite milk monitoring

Analyses of iodine–131 and strontium–90 concentrations in milk were made on a monthly basis. Of the 80 analyses for iodine–131, no sample was found to have a concentration greater than 20 pCi/liter, or 20 percent of the applicable concentration guide. Of the 73 milk samples analyzed for strontium–90, the maximum activity was found to be 26 pCi/liter, or 13 percent of the applicable concentration guide.

Offsite area monitoring badges

Offsite film badges were collected on a quarterly basis during the second half of the year. The maximum radiation dose at a single location for the entire six-month period, as measured by the film, was 75 mR of gamma and <20 mrad of beta radiation. For the purpose of calculating the maximum dose, each statistically zero result was assumed to be at the detection limit. The reported maximum is therefore conservatively estimated to be the upper limit of the true dose at that location. Nevertheless, this dose is well below the RPG for an individual residing in the vicinity of an atomic energy installation.

Wheat monitoring

In the 6 samples of wheat analyzed during the entire year, strontium–90 levels ranged from 7 to 30 pCi/kg with an average of 11 pCi/kg. Cesium–137 levels varied from 95 to 200 pCi/kg with an average of 155 pCi/kg. Manganese–54 concentrations varied from 500 to 1,200 pCi/kg with an average of 790 pCi/kg. The presence of these radionuclides in wheat is attributed to worldwide fallout resulting from the atmospheric testing of nuclear weapons. A comparison of data from 1964 with that from the previous years indicates that while the levels of strontium–90 and cesium–137 decreased by a factor of 3 to 5, the manganese–54 content almost doubled. Although there is no ready explanation for this increase, selective uptake of manganese from the soil might be responsible. Although specific guidance pertaining to wheat has not been established, the data indicate that wheat is not a significant contributor to the radiation dose received by the local population.

Previous coverage in *Radiological Health Data:*

Period	Issue
Second half 1960	*May 1961*
First half 1961	*January 1962*
Second half 1961	*June 1962*
Calendar year 1962	*June 1963*
Calendar year 1963	*September 1964*
First half 1964	*March 1965*

REPORTED NUCLEAR DETONATIONS, AUGUST 1965

During August 1965 two United States nuclear tests were announced by the Atomic Energy Commission. Tests in the low-yield range (less than 20 kilotons) were conducted underground at the Commission's Nevada Test Site on August 6 and August 27, 1965.